METALLURGIA

The British Journal of Metals
(INCORPORATING THE METALLURGICAL ENGINEER.)

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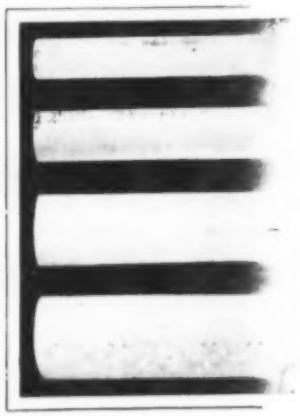

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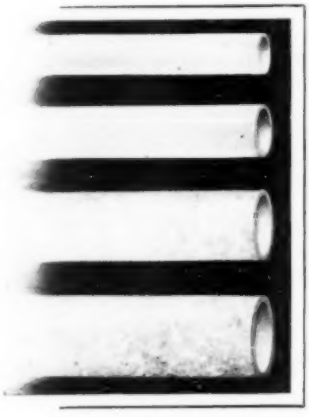

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THE BRITISH JOURNAL OF METALS.

INCORPORATING "THE METALLURGICAL ENGINEER".

FEBRUARY, 1935. VOL. XI., No. 64.

The Foundry Industry

By R. W. STUBBS,

President of the Institutes of British Foundrymen.

Competiton in recently developed materials and processes has been of inestimable worth in placing costing production in all metals and alloys on a more scientific basis. Mr. Stubbs is confident that the industry will make steady and progressive movement.

THE Englishman is not usually given to introspection, nor is he troubled with any lack of confidence in his own powers of achievement. Throughout the nineteenth century Britain's commercial, military and territorial power showed uninterrupted expansion and the permanence of her wealth and influence were accepted — at all events in this country—as an established fact.

Civilisation without metals is inconceivable. Metal working is the basis of culture and of all arts, and to a large degree the welfare of a nation is advanced in proportion to the state of perfection realised in its metal-working industry.

As is well known, the casting industry is an old one, dating back to prehistoric times. From these beginnings, castings of grey iron, of so-called semi-steel, chilled iron, malleable iron, carbon and alloy cast steels, and a multitude of brasses and bronzes, have been developed to a high state of perfection. In recent years these have been followed by the newer nickel-copper alloys, such as Monel metal, tin-nickel-copper alloys for greater hardness, silicon-copper and steels of nickel-chromium, chrome-tungsten, chrome-molybdenum, and various others of the more highly corrosion-resistant type.

While the casting industry has developed commercially to gigantic size, castings of a large variety of shapes and sizes being available for various purposes, other products — forgings, stampings, mouldings and welded products — some of them made by methods scarcely known even ten years ago —have come in to meet the multitudinous needs of present day industry.

Castings are being demanded of more intricate character, lighter construction, and with a higher quality of surface finish, and to be readily machinable at speeds much greater than hitherto. To attempt to cope with these conditions the progressive founder has been compelled to think very seriously how to so improve his methods of production as to enable him to satisfy the insistent demands of the consumer and meet the fierce bogey of competition.

The foundry equipment engineer has invented numerous improvements and developments which are quite equal to if not better than those of any of his foreign competitors, such as continuous moulding plants, electro-magnetic moulding machines, vertical core stoves drying in less time with greatly decreased fuel consumption, the rotary type of furnace using pulverised coal, recuperative oil fired furnaces for special mixtures, centrifugal casting machines for gear wheels, rings, etc., core and mould blowing machines sand preparation and handling, sand ramming machines, automatic cupola charging cranes, all of which have not been taken advantage of to anything like the degree anticipated owing to the acute financial malaise. With the assistance of all or any of the foregoing aids the economies which can thus be realised vary enormously in different foundries, and are obviously greatest in works producing more or less standardised commodities. The increase in mechanisation of all kinds compels the foundry to have practically speaking a tool room personnel to keep everything tuned to the required state of efficiency.

One of the propellers for the "Normandie" made by J. Stone & Co., Ltd., from Turbiston Bronze. Casting weight, 37 tons; finished weight, 23 tons.

Nevertheless, some foundries have been developing and extending the scope of their activities by quiet and continuous experiment and have everything in readiness to deal with increased output when the time comes, which proves that they still have faith in the future of the industry.

Experience in the past made one somewhat cautious in venturing an opinion for 1935. Many of the troubles of 1934 are unsolved, and there remains much to be done before we can return to the level of prosperity which science and invention have made possible. Yet, I think we may reasonably and confidently believe that things are looking up and can be expected to do so, and that 1935 will prove the beginning of a steady and progressive movement.

Foundry Plant and Machinery

Considerable progress has been made in recent years in the use of machinery to facilitate the production of castings, particularly in repetition work, which now embraces a large percentage of the work in the foundry, and in this article brief reference is made to some recent developments.

FOR long regarded as an industry in which manual dexterity played a primary part, the foundry is slowly, but surely, being involved in the tremendous advance of economical production made possible by the gradual development of machinery. Although modern machine methods have destroyed some of the crafts in which various types of skill have come to be embodied, they have not entirely destroyed the demand for that facility in manipulating the material in which skill essentially resides. In the foundry the tendency has been to design machines to relieve the foundryman of the heavy laborious work without relieving him of initiative necessary to determine ways and means for executing the work expeditiously and well. In some instances the mechanical appliances installed have resulted in slight readjustments because of responsibilities being transferred from the moulder to other workers, but generally the moulder is relieved of the heavy work, which enables him to concentrate his energies on the production of sound castings with as little effort as possible.

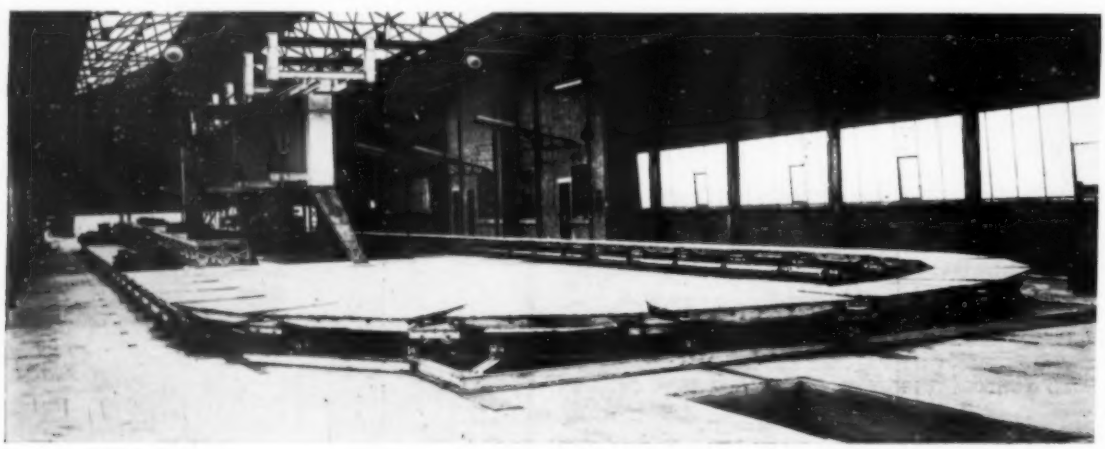


Fig. 1—A mechanised foundry equipped with a continuous casting system. The August's double bogie type mould conveyor is 400 ft. in length and weighs over 80 tons. It has a load carrying capacity of 150 tons.

The extent to which a foundry may be mechanised depends upon many factors, not the least important being the quantity, size and character of the castings to be made. Each foundry must be considered separately, and as the size of castings increases it becomes increasingly difficult to apply mechanised methods, because, generally, the number of similar castings is reduced and it is doubtful whether a particular installation would be an economical proposition. In some foundries, for instance, a section may be equipped to deal with repetition work on a fully mechanised plan, as in Fig. 1, production of moulds and the subsequent casting of them being more or less automatic. On the other hand the work of a foundry may be of a jobbing character and the castings varying much in size, in which case less equipment would be installed.

Sand Control and Preparation.

During recent years considerable attention has been given to the testing and control of moulding sands and about April last year, the British Cast Iron Research Association published recommended methods. On the other hand the Institute of British Foundrymen has recommended the American Foundrymens' Association test piece for foundry sand control. As a result of investigations and recommendations of certain approved methods, interest in the systematic testing of moulding sands is rapidly increasing. Suitable equipment for testing dry sands, oil sands and green sands, is supplied by Ridsdale and Co., Middlesbrough, the majority of which are recommended by the Institute of British Foundrymen. While equipment of this kind facilitates the production of sound castings and is especially valuable in mechanised foundries to control the sand mixture used, the mixing and handling of the sand used necessitates special equipment. For this purpose there are many types of equipment from the sand thrower, which is readily transported to any suitable position, to a central sand-preparing plant with facilities for transporting the prepared sand to convenient places in the foundry.

A typical example of sand-handling plant, of which many have recently been installed is shown in Fig. 2. These plants have been installed in non-ferrous foundries as well as iron and steel foundries. They are labour saving, affect considerable savings in new sand, reduce the amount of discard sand and what is, perhaps, their greatest feature from a metallurgical point of view, place the control of sand treatment and mixtures in the hands of the foundry management. With this plant operation is effected by one man, the size illustrated producing up to five tons of iron foundry facing sand per hour, or reconditioning up to 10 tons per hour of iron foundry moulding sand. It will also, with equal facility, prepare iron foundry loam or either naturally bonded or oil bonded core sands.

In practice the used foundry sand is conveyed to the plant usually, as illustrated in Fig. 2, by crane tubs and is dumped at the screen. From that point onwards until the sand arrives in the storage hopper the treatment is entirely automatic. The sand is screened, oversize and foreign matter being separated and collected; free iron is removed magnetically and the sand is de-silted, the silt being separated and collected also. The storage hopper, therefore, receives the used foundry sand which has been cooled, cleaned, screened, de-silted, and is now iron free. This sand we term basis sand as it forms the basis of all the ultimate sand mixtures. From this sand storage hopper the sand is drawn off, merely by lifting a door at

its base into the bucket of the bucket loader feeding a No. 2 Size August's Simpson Intensive Foundry Sand Mixer. The bucket, of course, at this stage rests with its lip at floor level, and after the requisite quantity of basis sand has been fed into the bucket the operator adds the correct quantity of new sand and coal dust without, of course, any preliminary mixing. The charge is then fed into the mixer where the correct quantity of water is added, controlled by a water meter, and after the requisite mixing times for that particular mixture have elapsed the discharge door of the mixer is opened and sand is automatically aerated in its passage from the mixer into the waiting crane tub which has been placed there to receive it.

The advantage of using scientifically prepared sands for the production of castings is generally recognised, and these prepared sands have become an essential feature of modern foundry practice. In the preparation of core sand and moulding sand efficient plant is now a necessity, not only to speedy production, but to ensure the adequate mixing of sand and bonding materials. A mixer which has been designed and developed to meet the most exacting demands is shown in Fig. 3. This machine gives complete and very rapid mixing, it aerates and discharges the sand and is suitable for any type mixtures. Designed in line with the best modern machine-tool practice this mixer has a low power consumption, negligible wear and tear, and operates without noise or vibration.

Moulding Machines

The types of moulding machines now in use vary considerably. They comprise machines which ram sand by slinging; jolt and squeeze machines operated hydraulically or by compressed air, which embrace both the plain and roll-over types; and also machines specially designed for special class of work such as pipes and pipe fittings. The sand slinger is concerned only with ramming sand and is of special value in jobbing foundries when jolt or squeeze machines are not a successful commercial proposition. The object of the sand slinger is to eliminate the laborious work of hand-ramming large or medium sized moulds and to effect economy in production.

The jarr roll-over pattern drawing machine is rather common, and one machine of this kind has a 26 in. × 42 in. turnover plate. It is equipped with pneumatic clamps for holding the mould during rolling over, and also automatic roll-off and length of gravity roller conveyor. The latter is arranged in such a way that as the pattern draw cylinder reaches its lowest position, a bottom board comes into contact with the roll-off arrangement, the mould then being rolled automatically on to a length of conveyer without handling. With this attachment, the machine is a complete unit and there is no time lost waiting for the crane to remove moulds before the operation can be repeated.

The bumper portion of this machine is of the latest impact design and gives a uniform density of blow in every position. Further there is no metallic shock, rebound, spring or wobble, and the beat of the bump is always regular irrespective of the length of time the machine has been in operation. Rolling over and pattern drawing on this machine are oil controlled and these operations are always perfectly steady and positive.

In addition to hydraulic and pneumatic machines several electrically operated machines are now available, such as the squeeze strip machine by Pneulec, Ltd. This machine is a magnetic moulder which takes power direct from the D.C. mains and requires neither compressor nor hydraulic equipment. Magnetic machines are claimed to be the most economical power squeeze moulding machines in the world, both with regard to power consumption and upkeep. It is equipped with electric vibrators and pattern plate heaters and in its design, special consideration has been given to the question of accurate pattern draw. With the corner guide rod principle employed in this machine, true alignment between the pattern and box during stripping can be guaranteed.

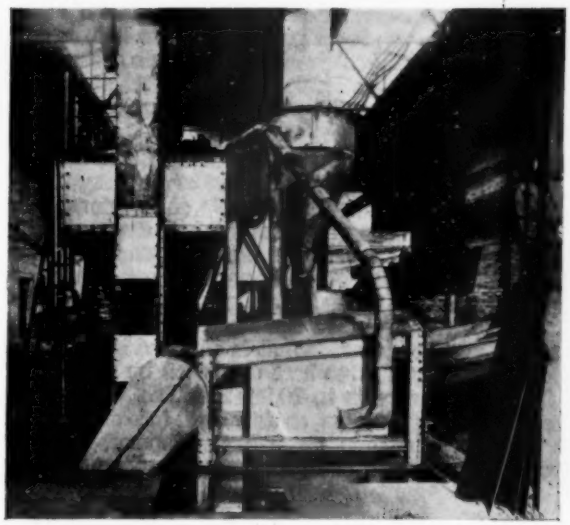


Fig. 2—Typical example of sand-handling plant of which many are now insta'led.

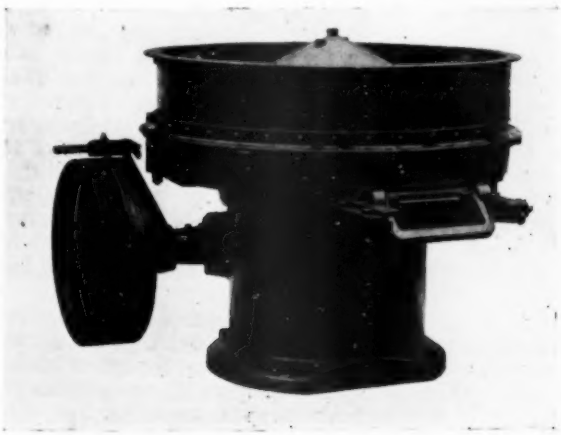
Melting Furnaces.

During the last few years probably the greatest attention has been given to melting appliances for cast iron. For general purposes the cupola has long been recognised as the most economical melting unit. Serious scientific attention has been given to this type of furnace with the object of securing maximum heat efficiency. It is recognised that an excessive quantity of air is not only bad practice, but has a deleterious effect upon the iron, and for a time the method of dealing with this problem was to cut down the excessive air or oxygen volume by having closer control of the air entering the furnace, that is, securing a closer relationship of the amount of air or oxygen entering in a unit time, to that theoretically required to burn a given amount of coke or carbon, the amount of the latter being again determined by the quantity of heat units required to melt a given amount of iron in a specified time. This closer control led to many improvements in cupola practice. It was, however, left to one or two investigators to realise that the ideal practice would be to carry out the main melting action in a reducing atmosphere, by maintaining an atmosphere of CO in the lower part of the furnace. To create and maintain such a reducing atmosphere is not an easy matter.

J. E. Fletcher, who had for some years been working on the theory that a reducing atmosphere was vital to the efficiency of practice and to the production of good, clean iron, free from oxidizing gases, says: "I started out with

Fig. 3.—A sand-mixer which has been designed to meet more exacting demands.

By Courtesy of the Fordarth Engineering Co., Ltd.



the idea and conviction that the air control should restrict the air supply to the lower part of the coke bed, so as to limit the amount of free air or oxygen of the gases in this zone to the lowest practicable percentage and, at the same time, to maintain the optimum carbon monoxide contained in these gases."

In order to complete the combustion of CO formed just above the lower tuyeres, further rows of auxiliary tuyeres were added to the balanced blast cupola, at heights sufficient to convert coke carbon at these levels to carbon dioxide, when supplied with air. It is the arrangement of these auxiliary tuyeres and the admittance of the correct amount of air through them which is, to a great extent, responsible not only for the superheat contained in the iron, but for some of the coke saving. What is obtained in practice is proved in theory, for the heat developed by the burning of CO to CO_2 amounts to 10,220 B.Th.U's., so that the descending charges of iron, as they come into contact with the heated air coming through the topmost auxiliary tuyeres, begin to melt and pass down through a gradually

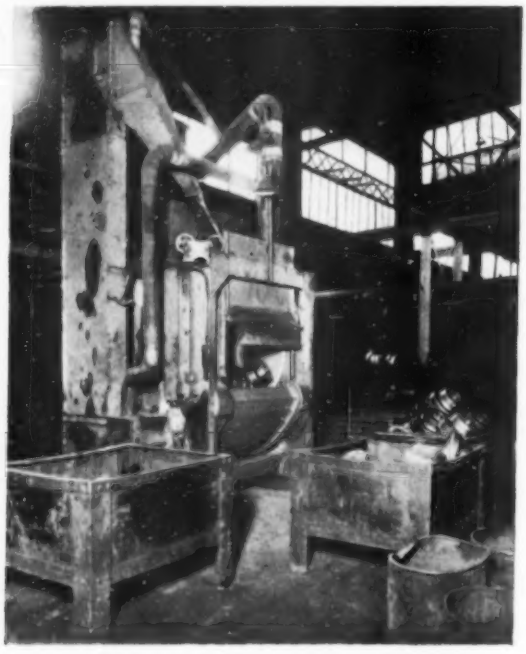


Fig. 4.—New type of cleaning equipment for castings.

increasing highly incandescent coke bed and become superheated in a reducing atmosphere in the lower part of the cupola. Thus the whole of the bed is effective as a melting medium.

Fletcher was the first to realise that to secure and maintain a properly balanced atmosphere, such as he required, would necessitate a specially designed cupola, particularly relating to the tuyeres, for these would all require to be adjustable in order to obtain the correct balance of air between the main and auxiliary tuyeres. From these investigations balanced blast cupola was developed and the British and foreign rights are the property of the British Cast Iron Research Association. Many of these cupolas are installed in this country and abroad with complete success in operation. Not only does the balanced draft cupola effect substantial economy in fuel costs but in the grey iron foundry it gives a clean, fluid and high temperature metal.

The use of electricity as a melting medium for cast iron is discussed elsewhere in this issue, but with the gradual development of special alloy cast irons the use of electric furnaces will increase particularly as the composition of a melt can be determined with great accuracy.

Cleaning Castings.

The application of sand-blast appliances to the cleaning of castings is well known, but a recent development of the American Foundry Equipment Co., shown in Fig. 4, claims to eliminate the compressed air, necessary for pressure-blasting equipment, and gives greater tonnage, faster cleaning and therefore lower operating costs. The equipment is known as the "Wheelabrator," for which Pneulec, Ltd., are sole licencees for manufacture and sale for the British Empire, excluding Canada. The abrasive in this equipment is thrown in a stream about 4 in. wide and the most effective working distance is 9 in. to 12 in. from the periphery of the wheel. The length of effective blast stream may be varied between 10 in. to 40 in.

The Wheelabrator head consists of a specially constructed wheel, in which shot is fed by gravity from a storage hopper. The shot is discharged at high velocity by centrifugal force, and due to the rate of discharge and effective area covered, the rate of cleaning exceeds that of high-pressure blasting. The abrasive can be placed wherever desired, either downward, upwards, or to right or left side of the wheel.

FINE CHEMICALS AT THE BRITISH INDUSTRIES FAIR.

AT the British Industries Fair, shortly to be opened at Olympia, a number of exhibits will have a direct metallurgical interest. In addition to the application of many metals and alloys developed during recent years, much interest is attached to the exhibits of The High Speed Steel Alloys, Ltd., of Widnes. This firm, a large producer of metals and alloys containing tungsten, molybdenum, and vanadium, have also a large chemical factory, and the exhibits include a wide variety of fine chemicals derived from these elements. A number of sodium tungstates are shown ranging from the commercial and anhydrous salts to the refined and chemically pure grades. Other tungsten compounds include several qualities of the trioxide which vary from the 96% commercial to the 99·9% WO_3 used as an intermediate for the production of pure tungsten powder for lamp filaments. Calcium tungstate is shown as the precipitated compound and also as the finely crystallised salt used in the preparation of X-Ray screens.

Ammonium and sodium para tungstates and the normal tungstates of barium, lead and potassium are also exhibited, while vanadium compounds are represented by varieties of the pentoxide, ammonium metavanadate and sodium ortho vanadate.

Molybdenum fine chemicals include sodium molybdate, crystallised and anhydrous, ammonium molybdate and molybdic acid, both the latter as ordinary and reagent qualities. Molybdenum trioxide, an intermediate in the manufacture of molybdenum metal, used for various electrical purposes and notably in wireless valves is also shown.

A development of recent years is the use of various forms of tungsten carbide to obtain hard surfaces, resistant to abrasion, on various implements used in agricultural or mining work and also in the preparation of cutting tools where a very finely divided and pure carbide is used in admixture with other metals. The types of tungsten carbide shown range from the crushed fused material to a product of particle size less than 1 u.

The Company is always prepared to consider the manufacture of any compound of vanadium, tungsten or molybdenum for which a commercial demand may exist and will welcome enquiries from parties interested in such compounds.

Another interesting exhibit will be that of Johnson Matthey and Co., Ltd., who, in addition to chemical products, are showing noble and base metals of various kinds and in many forms. A silver exhibit entitled "from ore to finished product" will have more than usual interest.

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RESEARCH AND CASTINGS PRODUCTION

Science is facilitating the work of the foundrymen in meeting more exacting demands, but further co-operation will give substantial improvements.

THE art of casting metals is very ancient; probably the oldest of metallurgical crafts. When it was first practised is uncertain, but, according to many fine specimens that have been found from time to time, the ancient Egyptians, the Chinese, Hindus, Greeks and Romans possessed no mean ability in the art. It is believed that the earliest castings were made from alloys of copper and many centuries passed before iron castings were produced and later steel castings, while the production of the light alloy castings, now so common, is still in its infancy. Development in the art, which made relatively slow progress up till the end of the nineteenth century, has since received considerable impetus, and during recent years remarkable progress has been made in the development of metals and alloys, which, in many cases, has been applied to the production of castings.

To-day, as a result of the development of fabricated structures, considerable competition exists in supplying the needs of the engineer and much progress has been achieved in meeting requirements with suitable castings. In the ferrous industry, for instance, there is rivalry between the producers of steel and iron castings which has become more acute as a result of the rapid development of high-duty cast irons during recent years. Since the British Cast Iron Research Association was formed, in 1921, much valuable work has been done to restore cast iron to a place of eminence among structural materials. From the castings point of view it is probable that more concentrated effort has been applied to improvements in the production of iron castings and although the results of research work in this field have not yet been applied as widely as desirable, there is no doubt that many foundries in Britain produce castings which possess qualities comparable with those produced in any other country.

Much research work has been done to determine the effect of alloying manganese, silicon, nickel, chromium, molybdenum, vanadium, titanium, and copper with cast iron, and alloys have been developed which, with or without heat-treatment, have properties very different from those cast irons formerly used. But recent investigations by the British Cast Iron Research Association promises further important progress. By a process worked out, it has been found possible to refine the graphite of normal or coarsely graphitic iron without any change in ordinary composition and without superheating to yield the graphite in the finest possible form. By a further process it has been found possible to recoarsen graphite. The successful application of this process will influence the method of producing pig iron and also the inoculated high strength irons which are a feature of recent developments.

With regard to steel castings it is no longer true that achievements in their production must be sought abroad because during recent years there has been very marked progress in the British steel founding industry and steel castings now produced are at least equal to those produced in other countries. Much investigatory work has been carried out on alloy steels, and in comparing the relative values of iron and steel alloy castings it should be emphasised that a good steel casting has a considerable amount of ductility, a desirable quality not characteristic of cast iron. It should be noted that research on steel castings, formerly carried out at the Research Department, Woolwich, under the supervision of the Metallurgy Research Board, is now the responsibility of the Industrial Research Council of the British Iron and Steel Industry and industrial co-operation in investigations is organised by it.

Aluminium and magnesium and their alloys are being increasingly applied in the form of castings and the rapid progress made is largely due to intensive research work in the development of alloys possessing physical qualities that render them eminently suited to a wide range of applications; improved technique in manufacture of suitable alloys has made standardisation possible, with the result that there is more confidence in the use of these alloys where their characteristic low relative weight is an advantage. The British Non-Ferrous Metals Research Association and the National Physical Laboratory have contributed to a better understanding of many of these alloys, while much valuable research has been carried out by individual firms.

The progress achieved in the production of iron and steel castings and in those comprising the light alloys has had its effect on the use of bronze castings, but despite keen competition copper alloys continue to be used as castings for a wide variety of purposes. The most important of these are the copper-zinc alloys, the copper-tin alloys and the copper-aluminium alloys all of which are extensively employed for general engineering purposes. In many instances these alloys are of a complex character and only careful research work has enabled a fuller realisation of the effect of each element in its relation to the mechanical properties of the alloy.

While the composition of the metal of which a casting is composed is important, other factors have a considerable influence on its usefulness. Probably the most important requirement of a casting is soundness. In many cases unsoundness condemns it, especially when it is in a vital part. The unsoundness may not be immediately apparent and much work may be put into a casting before defects are detected; thus, in addition to production costs, time and labour is expended involving further loss. Modern requirements demand castings capable of withstanding heavy duty and involve soundness as a primary consideration. The demand for a high degree of accuracy in casting dimensions is increasing, as a result of a desire to reduce machining costs, and allowances for this purpose are limited to a greater extent than formerly. In repetition work, castings of a similar size, type and design, are expected to retain uniformity in weight, and this is a very real difficulty to the foundryman. The ease by which a casting can be machined is another important factor. Speed in production is essential to lower costs and material assistance can frequently be given in the selection of suitable alloys of better machinability. Thus, it will be appreciated that, in addition to a knowledge of metals and alloys, the production of castings on a commercial basis should be kept in mind and proper co-operation maintained between the research worker and the foundryman.

THE MAGNITOGORSK METALLURGICAL COMBINE IN 1934

By a Russian Correspondent.

THE past months of the last year were months of severe tests to the Magnitogorsk Metallurgical Combine, which have been successfully withstood. Under the hard winter climate the Magnitogorsk plant has worked without interruption, and much better than in the previous year. During 1934 the Combine has completed the metallurgical cycle, from the ore and coke to the finished rolled metal. The results of the work during the first six months of that year are given by the following figures (in 1,000 tons) :—

	(In thousand tons.) First Six Months, 1934.	First Six Months, 1933.
Iron ore raised ..	1,491	785
Production of coke ..	729	311
Output of cast iron ..	526	167
Output of steel ..	0	187
Output of rolled metal	0	111

These figures testify to the remarkable growth in the output at the Magnitogorsk plant. Another important fact to be noted is that quality metal is beginning to play a considerable part in the output. Latterly, half of the rolled metal produced by the plant has been of a high-quality character. The increased output has been accompanied by greater efficiency in the working. This may be seen in the marked drop in costs of production. The average cost of production per ton of ore during the first six months of 1934 was 4 roubles 80 kopeks, as against an average of 6 roubles 40 kopeks for the whole of 1933. The production cost per ton of coke in the first six months of 1934 was 40 roubles, as against 50 roubles in 1933; the cost of production per ton of pig iron was 60 roubles, as against 80 roubles, and that of cast iron was 64 roubles per ton, as against 90 roubles per ton in 1933.

If the comparison in the average cost price of production during the six months of 1934 was made with the average for the first six months of 1933, then the reduction in production costs would be still more marked. This speaks for the greater efficiency of the Magnitogorsk workers in the utilisation of the advanced technical equipment of the plant.

A sum of 700 million roubles has already been expended in the building of the Magnitogorsk Combine. Nevertheless, it is still far from being complete. The Magnitogorsk ore mine is at present producing half of its projected capacity, and possesses approximately a quarter of the projected buildings for working up the ore. In the coking department only four of the projected 10 batteries have been built. Out of the eight blast furnaces projected only one is in operation; out of the three open-hearth shops projected only one has so far been built, and that not completely. In the rolling shop four rolling machines are in operation instead of the projected 15 (two machines are now in course of construction, and are expected to be put into operation at the beginning of this year.)

The Soviet Government has decided to complete the Magnitogorsk Combine at the end of the second five-year plan in 1937. When completed it will have an output capacity of 2,700,000 tons of cast iron; but in order to complete the plant an expenditure of a further 250–280 million roubles is necessary. This will bring the total cost of the Magnitogorsk works up to 1,000 million roubles.

Shovels made from monel metal are used by a large mining company in Chile to handle tamping for blast holes. Unlike steel shovels, they will not spark and set off the explosive prematurely. Furthermore, they resist the corrosive action of the tailing or residue from the leaching plant used as tamping material.

FORTHCOMING MEETINGS.

INSTITUTE OF METALS.

Mar. 6-7. Annual General Meeting held in the Hall of the Institution of Mechanical Engineers, Westminster.

Mar. 6. Annual Dinner and Dance. Trocadero Restaurant, W. 1.

BIRMINGHAM SECTION.

Feb. 28. "The Rarer Metals—Gold, Silver and Platinum," arranged by Messrs. Johnson, Mattley and Co., Ltd.

SHEFFIELD SECTION.

Mar. 8. "Electric Annealing and Heat-Treatment Furnaces," by A. G. Lobley, M.Sc.

SCOTTISH SECTION.

Mar. 11. "Welding," by T. H. Paterson, D.Sc.

SWANSEA SECTION.

Mar. 12. "Some Recent Developments in the Hardening of Non-ferrous Metals by Heat-Treatment," by W. T. Griffiths, M.Sc.

NORTH-EAST COAST SECTION.

Mar. 12. "The Improvement of White Bearing Metals for Severe Service; Some General Considerations," by D. J. MacNaughton.

LONDON SECTION.

Mar. 14. "Failures in Service," by H. J. Gough, M.B.E., D.Sc., Ph.D., F.R.S.

BIRMINGHAM SECTION.

Mar. 19. "Bearing Metals," by R. T. Rolfe.

SHEFFIELD.

Mar. 15. "Foundry Machinery with Particular Reference to Sand Handling Plant," by J. G. A. Skerl, D.Sc., and F. J. Cook, M.I. Mech. E.

WEST RIDING OF YORKSHIRE.

Mar. 9. "Complex Foundry Problems," by S. Carter.

AMERICAN SOCIETY FOR TESTING MATERIALS.

Mar. 6. Regional Meeting: Philadelphia, Pa., "Preservation Coatings for Structural Materials."

Mar. 4-8. Group Meetings of Committees—Philadelphia.

MANCHESTER METALLURGICAL SOCIETY.

Feb. 20. Presidential Address—Annual Meeting.

BIRMINGHAM METALLURGICAL SOCIETY.

Feb. 26. "Some Recent Metallurgical Developments," by Dr. L. B. Pfeil.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM.

Mar. 8. "The Founding of Manganese Bronze Propellers," by J. E. Newsum, M.Met.

EAST MIDLANDS.

Feb. 23. "Bells—Their History and Manufacture." (At Loughborough.)

LANCASHIRE.

Feb. 27. "How Welding has Displaced Castings in Manufacture by Fabrication," by J. Sadler.

Mar. 2. "Patternmaking—The Craftsman and his Craft," by H. Stead.

Mar. 6. "Making a Chemical Pan," by W. H. Meadowcroft. (At Preston.)

LONDON.

Mar. 6. "Pinholes in Aluminium Alloy Castings," by Capt. G. Mortimer.

MIDDLESBOROUGH.

Mar. 8. "The Use of Sodium Carbonate in Iron and Steel Works," by N. L. Evans.

NEWCASTLE-ON-TYNE.

Feb. 23. "The Making of Castings for Internal Combustion Engines," by A. L. Key.

SCOTTISH.

Feb. 23. "Refractories in the Foundry," by H. C. Biggs. (At Edinburgh.)

Mar. 2. "Some Recent Investigations on the Production and Utilisation of Metallurgical Coke," by Prof. H. L. Riley. (At Falkirk.)

Mr. E. H. Doughty, A.M.I. Mech.E., of British Timken, Limited, is to read a paper entitled, "The Tapered Roller Bearing, and Its Application to Rolling Mill Equipment," before the Rolling Mill Committee of the Verein Deutscher Eisenhüttenleute—the German Union of Iron Manufacturers—at Düsseldorf, on Tuesday, February 19.

Phosphor Bronze Castings—Their Production

By F. HUDSON,
Chief Metallurgist, Glenfield and Kennedy Ltd., Kilmarnock.

Phosphor bronze is often selected by the engineer for service under particularly arduous conditions embodying wear, corrosion resistance or a combination of both. It is extensively used for gear blanks, bearing bushes of all kinds, pump bodies, impellers, valve faces, steam and hydraulic rings, etc. Each application may call for a particular composition to give satisfactory service, but the majority of cases calls for specialisation in manufacture. In this article the author discusses some aspects of production which assist in developing adequate service life in various applications.

OUT of the general run of common brassfoundry alloys, phosphor bronze is often selected by the engineer for service under particularly arduous conditions embodying wear, corrosion resistance or a combination of both. Accordingly it is extensively used for gear blanks, bearing bushes of all kinds, pump bodies, impellors, valve faces, steam and hydraulic piston rings, etc. Furthermore, each application may call for a particular composition to give most satisfactory service, with the result that the term Phosphor Bronze now represents a class of alloy having widely varying chemical and physical properties, and in the majority of cases calls for specialisation in manufacture. This statement is not altogether appreciated as it is a relatively simple business to produce an apparent high grade casting, but quite a different matter to incorporate this point with the other necessary properties required to ensure adequate service life in the various applications demanded. Success in this direction can only be obtained by proper metallurgical control, backed up by intimate research and study into industrial requirements.

Phosphor bronze, as well as having a wide variety of composition, can be cast by various methods which profoundly affect the physical properties, and the question as to whether castings should be made centrifugally, by chill or sand, essentially depends on the type of casting and service conditions, and this point should, of necessity, be a subject of agreement between the Purchaser and the Manufacturer. To go intimately into such details is completely outside the scope of this article, and it is only proposed to deal with points as likely to be of general interest. Probably the first aspect of the production of castings in phosphor bronze is one of composition.

Composition.

Table No. 1, illustrates composition limits for various applications. It will be noted that in many of the compositions given, particularly those dealing with the leaded alloys, a percentage of nickel has been included, and this addition is there for a definite purpose. Whilst the addition of nickel is quite optional it has the effect of preventing lead segregation and also increases the resistance of the alloy to compression. High duty phosphor bronze should be free from antimony, bismuth, arsenic, zinc, sulphur and non-metallic inclusions, and this necessitates the use of high grade raw materials and carefully controlled melting conditions. Lead is not now recognised as an impurity in phosphor bronze, and for certain bearing applications imparts distinct advantages, particularly in facilitating "bedding down" in the larger types of industrial machinery using semi-hard or soft shafts. On the other hand the presence of zinc has a detrimental effect on the whole range of alloys as it reduces the anti-frictional properties of the metal and promotes "seizing." A good deal of information has been published by various investigators on the question of composition during the past few years, and it is not considered necessary to remark further on this aspect, except to point out that the use of too high phosphorus percentages is in many cases a disadvantage, as it causes low elongation values, and it should be the rule to employ the minimum amount of this element consistent with service requirements.

After composition comes melting practice. This is a particularly important aspect in the production of all non-ferrous castings and one which has not received the practical attention it merits. In the majority of foundries having trouble with phosphor bronze castings the fault probably lies in this section, and without a shadow of doubt more good metal has been spoiled in the melting operation than in any other. How few are the founders who have made a real study of this aspect and produce high grade metal with guaranteed physical properties, whilst the majority are having futile chemical analyses conducted on the raw materials supplied, with the idea of finding some trace of arsenic or other impurity and the hope of allocating blame thereon.

TABLE No. 1.

COMPOSITION LIMITS OF PHOSPHOR BRONZE FOR VARIOUS APPLICATIONS.

Application.	% Tin.	% Phosphorus.	% Lead.	% Nickel.
Bridge bearings, railway turntable centres, castings of maximum hardness with high-compression loads, dynamo and motor bearings	14·0 to 20·0	0·2 to 1·0	—	—
Aircraft and Admiralty castings	10·0 to 13·0	0·5 to 1·0	0·25 max.	—
Gear blanks, automobile axle bushes, miscellaneous castings, valve faces, bearing brushes, sheaves, etc.....	11·0 to 13·0	0·15 to 0·50	0·5 max.	0·5 max
Heavy-duty bearings for rolling mills, etc.	12·0	0·3	5·0	1·0
Machinery bearings for—				
Semi-hard shafts.....	10·0	0·3	8·0	1·0
Soft shafts	10·0	0·3	12·0	1·0
Drawn and rolled section—				
Bars, plate, wire, turbine blades, tube, etc.....	3·5 to 7·0	0·1 to 0·4	—	—

Melting Practice.

The fundamental law in the melting of phosphor bronze alloys is to *melt rapidly in a slightly oxidising atmosphere.* Many of the usual natural draught coke-fired pit type crucible furnaces in use in the majority of non-ferrous foundries are incapable of meeting this fundamental law unless special precautions are taken, and the proper conditions certainly cannot be obtained unless the true existing conditions have been investigated and determined in a scientific manner. It is not a difficult matter to have an analysis of the furnace atmosphere taken in order to be assured that a slightly oxidising atmosphere is an actual fact instead of a presumption. Furthermore, the mere statement that a slightly oxidising atmosphere is required for ideal conditions is, in itself, not sufficient as to be exact, the furnace atmosphere must be as far as possible, free from hydrogen and carbon-mon-oxide. In oil, gas or coke fired tilting furnaces, or in pit furnaces fitted with forced draught the correct atmosphere should not be difficult to obtain.

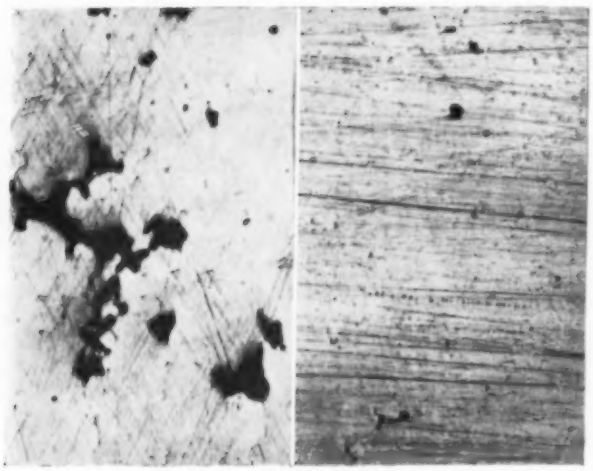


Fig. 1.—P 3. As polished. ×60. Porosity caused by slow cooling in conjunction with melting time of 160 mins. New metal heat.

Fig. 2.—C 3. As polished. ×60. Effect of rapid cooling on metal melted over period of 160 mins. New metal heat.

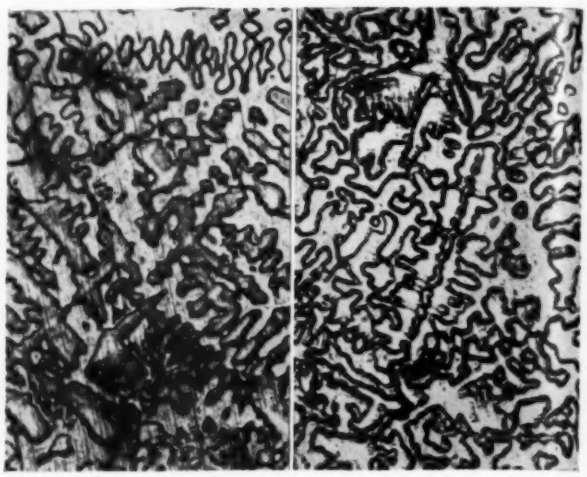


Fig. 3.—Test bar No. 3. Small type. New metal, heat-melted over a period of 160 mins. Sand cast. Etched ammonia. × 60.

Fig. 4.—Test bar No. 2. Small type. Re-melted metal, heat-melted over a period of 25 mins. Sand cast. Etched ammonia. ×60

A few months ago the writer had an experience on this question, which provides an excellent example of the problems being discussed. A new oil fired furnace had been started up, and it produced metal with consistently poor physical properties. The analysis of the furnace atmosphere was found to contain 12·0% carbon dioxide, no oxygen and 2·6% carbon monoxide, such being typical of a reducing atmosphere. By proper adjustment of the furnace controls the atmosphere was altered to give 14·4% carbon dioxide, 0·5% oxygen and no carbon monoxide, which is typical of a slightly oxidising atmosphere, and high grade metal was then produced. By noting the colour of the exhaust flame after the correct furnace atmosphere had been fixed a reliable practical guide to future operation was also obtained. Proper control of furnace atmosphere is undoubtedly most difficult to obtain in many natural-draught coke-fired pit type furnaces and unless the air supply is adequate it is probably advisable to fit forced draught under the fire-bars to obtain satisfactory results.

In regard to speed of melting it is always wise to aim for as rapid melting as possible, and if the furnace is not fast, considerable improvement can probably be obtained by ensuring that the crucible is well heated before charging the metal. If necessary this matter can be further accelerated by using short weight charges. A good average melting time for phosphor bronze cast in sand moulds should be around 1 to 1½ hours, whilst for chill cast work greater latitude may be given. It is also interesting to note that this greater latitude also applies to charges containing a high percentage of remelted scrap.

Tables Nos. 2 and 3, show the effect of melting time on the physical properties of a typical phosphor bronze cast from new metal and remelted scrap using various forms of test bars. The composition adopted conforms to B.S.I. Specification No. 421, Phosphor Bronze Castings for Gear Blanks, and the following conclusions can be made :—

1. In Table No. 2, using new metal heats, satisfactory physical properties were obtained on chill cast bars, even with melting times up to 160 minutes, whilst in the case of sand cast bars satisfactory results were only obtained on test bar type No. 2, with a melting time of 50 min. The effect of melting time on sand cast bars being most marked.
2. In Table No. 3, using twice melted metal, the effect of melting time up to 130 mins. is not pronounced, and the physical properties of sand cast test bars in this series after melting time of 130 mins. are in every case satisfactory and superior to a melting time of 50 mins. using new metal heats.

It is obvious that the employment of chill moulds and twice melted metal, play a very important part in minimising the detrimental effect of prolonged melting periods, and promotes uniformity in physical properties obtained between various types of test bars. In the series of test results made from new metal heats, test bar type No. 3, gives slowest cooling conditions, and this enormously magnifies the ill effects of melting conditions as will be observed from a comparison of photo-micrographs Nos. 1 and 2, showing the porosity present in bronze cast in this manner in comparison to rapidly cooled bars with 160 mins.

TABLE No. 2.

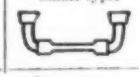
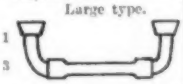
EFFECT OF MELTING TIME AND FORM OF TEST BAR ON CAST PHOSPHOR BRONZE.

NEW METAL HEATS.

85% best selected copper, 11% pure tin, 4% phosphor copper (10%).

Analysis—	1, P 1, C 1.		3, P 3, C 3.
	%		%
Copper	88·49	..	87·95
Tin	11·20	..	11·73
Lead	trace	..	trace
Phosphorus	0·22	..	0·25

Casting temperature of test bars, 1,020—1,050° C.

No.	Type of Test Bar.	Melting Time in Mins.	Diam. of Test Bar, In.	Tons per Sq. In. M.S.	Tons per Sq. In. Y.P.	Elongation, %.	Brinell Hardness at 1,000 kilogs.	Density.
	Small type.					on 2 in.		
1		50	0·564	16·0	10·4	5·5	92·3	8·50
3		160	0·564	14·2	9·8	2·0	84·9	8·44
	Large type.					on 3 in.		
1		50	0·798	18·0	11·0	12·5	89·7	8·76
3		160	0·798	13·4	10·0	4·0	82·6	8·61
	Pressure type.					on 2 in.		
P 1		50	0·564	14·6	10·4	6·0	94·9	8·66
P 3		160	0·564	12·8	12·0	3·0	84·9	8·56
	Chill cast.					on 2 in.		
C 1		50	0·564	25·0	13·4	24·5	92·3	8·81
C 3		160	0·564	24·2	13·4	17·0	112·0	8·84

Heat Nos. 1—P 1—C 1, melted in Morgan oil-fired furnace and poured into crucible at 1,180° C. superheat.

Heat Nos. 3—P 3—C 3, melted in coke-fired pit furnace and crucible drawn with 1,200° C. superheat.

All test-bar moulds made in dry sand except chill-cast bars.

melting time. It is also interesting to note the general structure of bronze which has been subject to prolonged melting periods in comparison to faster melted material as shown in photo-micrographs Nos. 3 to 10.

At this juncture it might be wise to review the points, so far as melting practice is concerned, requiring attention

Fig. 5.—Test bar No. 3. Large type. New metal, heat-melted over a period of 160 mins. Sand cast. Etched ammonia. × 60.

Fig. 6.—Test bar No. 2. Large type. Re-melted metal, heat-melted over a period of 25 mins. Sand cast. Etched ammonia. × 60.

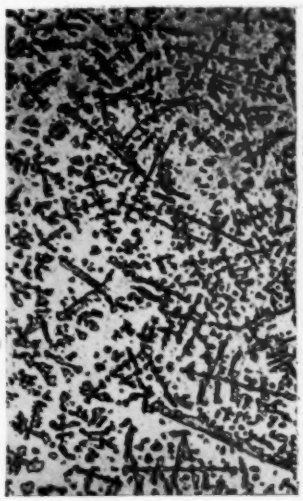


Fig. 9.—Test bar No. C 3. Chill cast. New metal, heat-melted over a period of 160 mins. Etched ammonia. × 60.

Fig. 10.—Test bar No. C 2. Chill cast. Re-melted metal, heat-melted over a period of 25 mins. Etched ammonia. × 60.

to ensure production of high class phosphor bronze :—

1. Employ raw materials of recognised purity and use remelted metal as much as possible.
2. Ensure correct atmosphere during melting.
3. Melt as fast as possible, consistent with the production of uniform metal.

Casting Temperature.

Following the question of melting practice the next aspect is that of casting temperature.

The limits of casting temperature in average practice can be placed between 1,020° C. and 1,100° C. The golden rule is to cast at the lowest possible temperature consistent with complete filling of the mould. Consistently high physical properties can only be obtained in sand cast phosphor bronze by careful control of this factor.

In regard to small sectioned chill casting production, greater latitude is permissible as will be observed from the test results shown in Table No. 4. Good physical properties alone, however, are not the only criterion in commercial casting production, and for the larger chill casting sizes it pays to control casting temperature accurately in the same manner as for castings made in sand. A common defect due to pouring large chill castings too hot is that of shrinkage cavities in the vicinity of gates or risers. Two fairly good practical tests of value in checking if satisfactory casting temperatures have been employed is in one case to note the time from the filling of the riser basin to surface solidification of the metal therein. If this takes place within 15 secs. the casting temperature can be relied upon as being correct. The second test is to note the appearance of the solidified surface of the riser or feeding head, which should be similar to that shown in Photograph No. 11.

TABLE No. 3.

SECONDARY METAL HEATS.

Scrap from new metal heats plus phosphor copper.

Analysis—	2, P 2, C 2.	4, P 4, C 4.
	%	%
Copper	88·54	88·42
Tin	11·19	11·34
Lead	trace	trace
Phosphorus	0·23	0·16

Casting temperature of test bars, 1,020—1,050° C.

No.	Type of Test Bar.	Melting Time in Mins.	Diam. of Test Bar, In.	Tons per Sq. In. M.S.	Tons per Sq. In. Y.P.	Elongation, %	Brinell Hardness at 1,000 kilogs.	Density.
	Small type.					on 2 in.		
2		25	0·564	17·2	12·4	5·0	92·3	8·77
4		130	0·564	18·8	13·0	8·25	94·9	8·80
	Large type.					on 3 in.		
2		25	0·798	14·45	9·8	5·0	93·6	8·69
4		130	0·798	16·1	10·5	7·25	94·9	8·78
	Pressure type.					on 2 in.		
P 2		25	0·564	17·6	11·8	12·0	85·0	8·61
P 4		130	0·564	16·0	11·6	7·75	92·3	8·71
	Chill cast.					on 2 in.		
C 2		25	0·564	22·0	13·0	11·5	108·5	8·78
C 4		130	0·564	20·6	13·6	8·75	110·5	8·88

Heat Nos. 2—P 2—C 2, melted in Morgan oil-fired furnace and poured into crucible at 1,080° C. superheat.
Heat Nos. 4—P 4—C 4, melted in coke-fired pit furnace and crucible drawn with 1,120° C. superheat.
All test-bar moulds made in dry sand except chill-cast bars.

TABLE No. 4.

EFFECT OF CASTING TEMPERATURE ON CHILL-CAST BARS.

Analysis—	%	Charge—	%
Copper	87·85	Best selected copper	85
Tin	11·79	Pure tin	11
Lead	trace	10% phosphor copper	4
Phosphorus	0·28		

Casting Temperature ° C.	Diam. of Test Bar In.	Tons per Sq. In. M.S.	Tons per Sq. In. Y.P.	Elongation % on 2 in.	Brinell Hardness at 1,000 kilogs.	Density.
1,150	0·564	21·6	13·2	18·0	101	8·77
1,100	0·564	24·0	14·8	24·0	107	8·91
1,050	0·564	22·8	15·2	14·0	114	8·93
1,000	0·564	23·2	13·2	10·5	114	8·93

Melting time 85 mins., in coke-fired pit fire.
Drawing temperature, 1,220° C.

Mould Materials and General Casting Production.

As previously pointed out in this article, the question of mould materials has a very great effect on the quality of phosphor bronzes. Castings made in sand show up any deficiency in melting practice to the fullest extent and if sound castings are to be made by this method it is absolutely necessary to have perfect melting practice. On the other hand, chill castings permit of less rigid control in melting and consequently their use should be emphasised as much as possible. In many instances, however, it is not possible or economical to employ chill moulds, and there is consequently a considerable need for a moulding material having high heat conductivity. Research in this direction could be directed in the use of a plastic moulding composition, made up from fine iron or steel shot, graphite, or carborundum sand with a suitable binder. The constituents could be used separately or in admixture according to requirements and sodium silicate used for binding purposes when permanency is required, whilst for collapsible internal

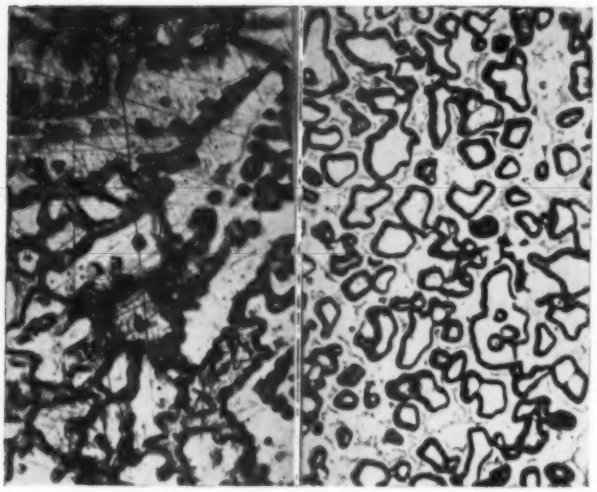


Fig. 7.—Test bar No. P 3. Pressure type. New metal, heat-melted over a period of 160 mins. Sand cast. Etched ammonia. × 60.

Fig. 8.—Test bar No. P 2. Pressure type. Re-melted metal, heat-melted over a period of 25 mins. Sand cast. Etched ammonia. × 60.

cores one of the many excellent proprietory core oils at present on the market would no doubt successfully meet the bill. For simple symmetrical castings such as gear wheel blanks, bearing bushes, etc., chill segments or complete moulds can be conveniently used with excellent results.

Photographs No. 11 and 12, show a typical method of casting a gear wheel rim by such methods. In this particular instance the casting was made in dry sand with six chill segments adjacent to the outer periphery of the rim. The photographs also show the position of the runner, riser and chilled test bar. This is a particularly satisfactory way of making gear wheel blanks from the production view point as it is easily possible to obtain physical tests from 17·0 to 22·0 tons ultimate stress with 9 to 22% elongation according to available technique. It is, however, a mistaken idea that in chill castings of this type it is feasible to reduce the size of gates and runner, and dispense with the need of risers. For castings made in sand moulds with extensive chill inserts the freezing of the metal is by no means progressive, and feeding facilities should be supplied to cover the whole casting area, at points furthest removed from the chilled surface.

When the use of chill segments or moulds is not a suitable practical proposition small castings can be made quite successfully in skin-dried green sand moulds having a suitable surface dressing to prevent metal penetration, and in the case of larger castings the use of dry-sand is more or less standard. The sand question as applied to the production of phosphor bronze castings is essentially one of surface finish. All moulds should be constructed in such a manner that surfaces in contact with the metal are dense enough to resist the fluidity of this class of alloy. Undoubtedly the best results are obtained when a close grained facing sand is used next to the pattern, backed up with a more open backing sand. The physical properties of such sands can be specified as follows :—

Dry Sand.	Facing.	Backing.
Moisture, %	6 to 10	6 to 10
Green compression, A.F.A. lb. per sq. in.	4 to 6	4 to 6
Dry compression, A.F.A. lb. per sq. in.	100	100
Dry permeability, A.F.A. No.	15 to 20	60 to 80

After drying, the mould surface should receive an adequate coat of blackwash. The same sand mixtures can be used for cores if desired.

The question of penetration has in the past been a decided detriment to the use of oil sand cores in this branch of non-ferrous founding, and it is particularly interesting to note that within recent years considerable advances have been made in this direction in relation to the production of chill cast cored phosphor bronze sticks for the automobile and allied industries. In the majority of cases such cores are produced in a Rotary Core machine in long lengths having diameters from $\frac{3}{16}$ in. upwards, and down the centre of each core is a small hole to take the rod required for strengthening purposes. In some cases the core sand is actually extruded direct on the rod. By courtesy of the Fordath Engineering Co., West Bromwich, who have made a particular study of this class of work, the following oil sand core mixtures have been supplied as being suitable for use with phosphor bronze castings :—

USUAL RUN OF SAND CASTINGS—

19 parts sea sand or suitable silica sand.
6 parts red sand (Stourbridge or Mansfield medium).
1 part glyso S.S., by volume.
2½ to 3% water.

CORES FOR CHILL CAST STICKS PRODUCED ON ROTARY CORE MACHINES—

28 parts sea sand or suitable silica sand.
4 parts red sand (Stourbridge or Mansfield medium).
1 part glyso S.S., by volume.
½ part permol, by volume.
2% water.

Fig. 11.—Showing method of casting 18 in. gear-wheel rim with working face chilled.

The great necessity is to black the cores with suitable black wash, and the same Company market a special core wash for use with phosphor bronze. This wash should also be eminently suitable for coating moulds and chill inserts.

So far as casting and moulding practice is concerned the points to watch in the production of high class phosphor bronze can be stated as follows :—

1. Employ correct casting temperature for the job on hand.

2. Use chill moulds or chill inserts as much as possible as the rapid cooling obtained thereby tends to reduce the detrimental effects of
   - A. High percentage new metal in charges.
   - B. Incorrect furnace atmosphere.
   - C. Prolonged melting periods.
   - D. Effects of casting temperature.

3. In the production of sand castings use moulding materials of high heat conductivity as much as possible, and pay particular attention to the correction of points A, B, C, D, stated above.

So far all the aspects dealing with the production of phosphor bronze castings have been in connection with manufacture or physical properties connected with mechanical operation, and in conclusion it is perhaps wise to draw attention to the value of phosphor bronze from the corrosion viewpoint. Corrosion tests recently conducted by the author indicate that this alloy has quite a high value for service in domestic and industrial waters, as shown in Table No. 5, and no doubt there is a considerable field open for extension in this direction. It is considered that whilst the wearing and frictional properties of phosphor bronze have earned undoubted recognition the corrosion resistance is inclined to be overlooked and as a result the full value of this alloy is not obtained in engineering. In the field of Hydraulic Engineering, where metallic parts suffer severe depreciation through the combined effects of wear and corrosion many opportunities exist for improvement in the class of metals used, and there is no doubt that high-class phosphor bronze castings will be utilised more extensively in the future to replace the more common but easier cast gunmetals, in such parts as valve faces, etc., giving improved service at economical cost. In the past the average non-ferrous founder has perhaps found the production of high-class phosphor bronze castings a difficult matter through inappreciation of many of the aspects in their production, and this has retarded the advance of a valuable and important group of alloys to a considerable extent.

TABLE No. 5.

CORROSION VALUES FOR PHOSPHOR BRONZE.

Alloy.	Loss in mg. per 100 sq. cms. per 24 hrs. at 60° F. in aerated Tap Water.	River Water.	Sea Water.
Cast phosphor bronze	0·85	0·84	11·98
Cast gunmetal	1·36	1·13	12·33
Cast yellow brass	1·91	1·46	7·02
Forged manganese brass	2·68	1·95	11·93
Forged aluminium bronze	1·42	0·73	2·37
Forged Monel metal	0·93	0·51	3·12
Forged cupro nickel (80/20)	1·70	1·17	2·01
Cast nickel silver	1·89	1·47	4·08
White bearing metal (Admiralty)	1·59	2·41	14·14
Copper	1·78	1·15	7·05
Aluminium	2·88	4·19	15·22
Lead	22·05	33·12	40·61
Tin	1·49	2·12	13·60
Zinc	28·32	15·70	20·32
Cast iron	74·82	55·03	35·02
Mild steel	61·49	39·25	41·44
Stainless steel (12% Cr.)	0·21	0·11	25·64
Staybrite steel	No loss	0·11	No loss

WELDED STEEL FRAMES

Fabricated structures are of considerable importance in economical production, they give adequate strength and rigidity with a substantial reduction in weight, and are now being applied as frames for marine oil engines.

MODERN electrical appliances and processes, together with the practical diligence of the operating welder, has made such remarkable progress in recent years that welding has now become a very important industry. The size and variety of work now being accomplished and the increasing use of welded structures, in work for which iron and steel castings were formerly used exclusively, speaks volumes for the progress achieved in welding. For many structures there seems little doubt that the use of fabricated steel has marked advantages over castings. In the first place, the expense of pattern work is totally eliminated, a factor of considerable importance in economical production, and as structures can be given adequate strength and rigidity with considerably less weight, the method saves in material.

Fabricated structures are free from those defects to which castings are subject. The possibility of blowholes, shrinkage cavities, or shrinkage strains, which may render a casting useless, is not likely to affect a welded structure. There are also advantages of design and quality.

Probably the most notable illustration of the developments in welded structures is that effected in the design and manufacture of electrical equipment. Many important applications of welded construction have been developed in this industry which have now become normal practice. These include frames for turbo-alternators and other large machines, the shells of steam condensers and evaporators, bedplates and pedestals, etc. Considerable development also has taken place in the application of welding to ship construction and marine engineering. That much progress has been achieved in the latter industry is indicated by Mr. J. Hamilton Gibson, O.B.E., in a paper read before a recent meeting of the Institute of Marine Engineers. Mr. Gibson dealt with the design and production of welded steel frames for marine oil engines of the four-stroke type for main and auxiliary purposes, and explained the method of construction in which primary loads are not transmitted through the welding. A description was given of three types of frames as actually constructed for main engines, as well as some auxiliary engines. It is noteworthy that all frames when completed are submitted to a heat treatment consisting of heating up to 650° C., and maintaining that temperature for one hour for every inch of thickness of the thickest plate used, and then cooling off in still air. No difficulty has been experienced in carrying out this treatment, and no deformation has taken place.

It has been found possible, in all designs discussed, to construct the welded steel work in such a manner that the various details of fittings and moving parts have not had to be altered from the original designs of the engines. This is an important advantage when considering a change over from castings to steel weldings for an existing design of engine. As regards weight, Mr. Gibson pointed out, generally there should be a saving of about 60% in comparison with cast iron and not less than 10% in comparison with cast steel. The weight of the main frame is controlled by the permissible amount of elastic stretch under the primary load. This can only be fixed by the designer and as a result of some experience.

The steel used in frames described is of 24 to 28 tons ultimate tensile strength with a yield point of around 14 to 16 tons and an elongation of 25% in 8 in. The carbon content is low, not exceeding about ·15%. This quality of steel is, therefore, excellent for electric arc welding, and electrodes are used which give approximately the same physical properties as the parent metal.

Reviews of Current Literature.

The Alloys of Iron and Copper.

IRON base alloys containing copper are of comparatively recent origin, probably the most notable investigations of the properties of these alloys relate to corrosion resistance, and extensive exposure tests of copper-bearing steels conducted in Germany and the United Kingdom proved that the addition of as little as 0·2% copper to low carbon wrought materials appreciably increased the resistance to atmospheric corrosion. As a result of these investigations a number of steels containing copper have been developed for structural purposes. In addition to copper they may contain small percentages of nickel, chromium, molybdenum, and other alloying elements, and under certain conditions these steels have greater resistance to corrosion than mild steel and have a higher tensile strength at ordinary and at high temperatures. More recently investigators have shown that iron-rich alloys containing copper can be hardened by inducing precipitation and that such a treatment may find commercial application. The alloys are somewhat unusual in that they need not be quenched in order to produce a supersaturated solution, so as to be in condition for the precipitation treatment. Air-coo'ed as well as quenched samples can, therefore, be hardened by reheating to a temperature in the neighbourhood of 500° C.

Generally the copper-bearing steels, containing about 0·25% copper, are now well known and widely used for structural purposes and sheet. A number of copper alloy steels such as copper-chromium, copper-manganese, and copper-molybdenum are being applied to an increasing extent. Investigatory work in Germany has shown that copper-chromium steels, containing approximately 0·6% copper and 0·3% chromium, have a high yield strength in the as-rolled condition, and that as a result they provide an economical structural material.

Although the application of copper as an alloying element in steel is not very widely appreciated, the important results from investigations point to its more extensive use, especially in view of the fact that it is one of the cheapest of materials for this purpose and that only relatively small amounts are required to confer desirable properties. Full information on the important work done is given in this new volume which is the fourth of the monograph series on Alloys of Iron Research. Not only does it give full information of the work done on the effect of copper on the properties of steels, but also on cast iron, wrought iron, malleable iron, and complex alloyed steels and cast irons.

In a chapter which deals with the melting and working of copper irons and steels, it is shown that the processes are essentially the same as for copper-free metals. Copper may be added to molten iron or steel in the form of metal, scrap, copper-steel scrap, or cupriferous ore. The metal may be added at any time during the making of a heat, preferable to the furnace. Commercial copper steels with usual manganese and sulphur contents can be forged and rolled without difficulty, if the copper content does not exceed about 2%. Cracks appear on the edges or even on the entire surface of steels containing as little as 0·2% copper during forging or rolling at temperatures above about 1,095° C. These are due to intergranular penetration of copper deposited under the scale as a result of preferential oxidation of iron during heating as for forging or rolling. Investigations, however, have shown that surface cracking may be practically eliminated by the addition of small amounts of nickel, by rolling below the melting point of the copper-rich solid solution, or by preventing the formation of scale while the steel is being heated to the working temperature.

This book is a valuable addition to the monograph series not only because of the informative description of work done on the effect of copper on ferrous materials but because the authors have been at considerable pains to develop the practical results for convenient application. It embraces a very comprehensive survey of the subject and it is noteworthy that, in addition to correlating published data, it contains much work that is published for the first time. In keeping with this series the book carries a bibliography comprising 399 selected references, and it is noteworthy that these include the results of work published in 1934.

By J. L. Gregg and B. N. Daniloff; published by McGraw-Hill Publishing Co., Ltd., Aldwych House London, E.C. 4. Price 30s. net.

ANNUAL MEETING OF INSTITUTE OF METALS.

THE Twenty-Seventh Annual General Meeting will be held in the Hall of the Institution of Mechanical Engineers. Storey's Gate, Westminster, S.W. 1., on March 6 and 7. Several papers will be presented for discussion at the technical sessions, those on the morning of March 6, including :—" Corrosion-Fatigue Properties of Duralumin with and without Protective Coatings " by I. J. Gerard, M.Sc., and H. Sutton, M.Sc. " Some Further Experiments on Atmospheric Action in Fatigue " by H. J. Gough, M.B.E., D.Sc., F.R.S., and D. G. Sopwith, B.Sc., " The Effect of Five Years' Atmospheric Exposure on the Breaking Load and the Electrical Resistance of Non-Ferrous Wires " by J. C. Hudson, D.Sc., D.I.C. " The ϵ γ and β Phases of the System Cadmium-Silver " by P. J. Durrant, M.A., Ph.D.

Further papers to be presented at an afternoon session include : —" The Penetration of Steel by Soft Solder and Other Molten Metals at Temperatures of not over 400° C " by Van Ewijk, L. J. G., Dr. ir. " Type Metal Alloys." by Weaver, Frances D., B.Sc. " The Constitution and Properties of Cadmium-Tin Alloys " by Hanson, Professor D., D.Sc., and W. T. Pell-Walpole, B.Sc. " Some Properties of Tin Containing Small Amounts of Aluminium, Manganese or Bismuth " by Hanson, Professor D., D.Sc., and E. J. Sandford, B.Sc.

On the following day, March 7, at a morning session, the papers include : —" The Reduction by Hydrogen of Stannic Acid contained in H.-C. Copper " by W. E. Alkins, D.Sc., and A. P. C. Hallowes. " Unsoundness in Aluminium Sand Castings. Part III. —Solidification in Sand Moulds under Pressure " by Professor D. Hanson, D.Sc., and I. G. Slater, Ph.D., M.Sc., " Alloys of Magnesium. Part II. — The Mechanical Properties of Some Wrought Magnesium Alloys " by W. Prytherch, M.Sc. " The Spectrographic Analysis of Aluminium " by D. M. Smith, B.Sc., D.I.C

Discussion on Cold-Presswork

In the evening before the Annual General Meeting there will be held in the Hall of the Royal Geographical Society, Kensington Gore, S.W. 7 (Exhibition Road entrance), a Joint Meeting to discuss the subject of " Cold Pressing and Drawing." Sir Harold Carpenter, F.R.S. will preside. The meeting is being organized by the Institution of Automobile Engineers in co-operation with the Institute of Metals and the following other societies : Iron and Steel Institute, Chemical Engineering Group, Institute of Fuel, Institute of Marine Engineers, Royal Aeronautical Society, Institution of Mechanical Engineers, Institution of Petroleum Technologists, Society of Engineers, Junior Institution of Engineers, and the North-East Coast Institution of Engineers and Shipbuilders. The discussion of the subject will be opened by two papers to be read, respectively, by Dr. H. J. Gough, F.R.S. (Superintendent of the Engineering Department of the National Physical Laboratory) and by Dr. Cecil H. Desch, F.R.S. (Superintendent of the Metallurgical Department of the National Physical Laboratory). Dr. Gough will deal with the mechanical problems involved and Dr. Desch with the metallurgical aspect.

The Electric Melting of Cast Iron

By A. G. Robiette, B.Sc.

Being confronted with intensive competition as a result of the remarkable advances made in welding, drop forging, and stamping practice, the grey-iron industry was threatened with extinction until research had shown that this material with, and even without, slight changes in composition was capable of assuming physical characteristics approaching, and even surpassing, those normally encountered in cast or forged carbon steels. The rapid developments in the metallurgy of light alloys had also made encroachments upon the grey iron field. The electric furnace has played no insignificant part in the new outlook for grey iron, and it is proposed here to review the melting treatment and practice for modern high-duty irons.

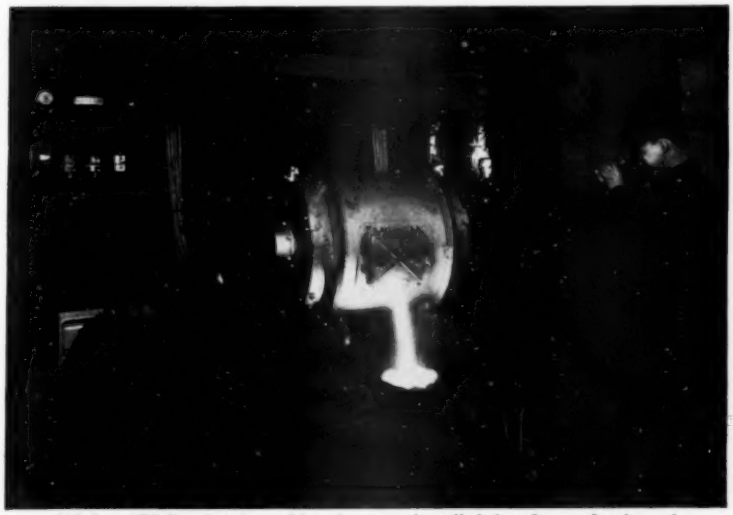
GREY cast iron consists essentially of a groundmass analagous to that of steel, in that it may assume ferritic, pearlitic, sorbitic or martensitic structures, but in this groundmass are interspersed particles of primary graphite. The form and distribution of this graphite has an important bearing upon the physical properties of the iron. If it occurs as large flakes or plates, often intersecting one another, these will constitute planes of cleavage or weakness and the tensile properties will suffer. To improve the physical characteristics of an iron, the primary object is to obtain a structure, consisting of finely divided graphite particles, preferably in a nodular or rounded form. It was pointed out many years ago by Johnson[1] that irons made by adding blown Bessemer metal to cupola iron possessed structures embodying nodular graphite, whilst the tensile properties far exceeded those obtainable from the normal cupola product. He attributed this to the presence of oxygen, but it has since been learnt that it was due to the combined influence of superheat (owing to the high temperature of the blown metal) and the lower total carbon content. It has long been known that if molten cupola metal yielding coarse graphite flakes is superheated from about 1,400° C. to 1,600–1,625° C., the resulting metal will show a finely divided graphite structure.

The generally accepted explanation of this phenomenon, although it does not reconcile certain facts, is that when an iron is superheated the graphite flakes become completely dissolved in the melt, with the result that there are no nuclei left on to which the carbon can be deposited and thus grow. The precipitation of graphite is therefore inhibited until the iron has reached a temperature below the solidification range—in other words a " super-saturation " effect is produced. The graphite is then immediately deposited from a large number of centres, and as this crystallisation now takes place in a groundmass possessing a certain amount of rigidity, its form will be rounded instead of lamellar. If a pouring temperature in the region of 1,600° C. is undesirable for certain castings, the iron, once superheated, can be cooled to a lower pouring temperature, and still give a refined structure. Other attendant advantages of superheating are increased fluidity and the ability to cast thin intricate sections without having recourse to raising the phosphorus content thereby inducing brittleness. Superheat also improves the effectiveness of risers and feeders.

Control of composition, especially with regard to the C/Si ratio, is equally important, whilst the value of low total carbon irons has been increasingly appreciated since the adoption of electric melting. Silicon promotes graphitisation and if the content of this constituent is so regulated that the balance of the carbon, after graphite separation, is approximately the eutectoid composition, the groundmass will be completely pearlitic and the iron will have practically the strength of a pearlitic steel. In this manner, together with the adoption of superheat, it has been possible to increase the strength of plain unalloyed castings from 10–12 tons/sq. in. to 22–26 tons/sq. in. It will also be realised that with suitable heat treatment a martensitic or sorbitic groundmass can be attained. If free machining properties are desirable, it may be advisable to sacrifice strength by increasing the silicon and thus obtain a ferritic structure. The C/Si ratio will, of course, depend upon the section of casting, the ultimate properties desired, and the content of other elements, especially Mn, Cr and Ni.

Alloying Elements in the Iron Foundry.

A further notable development in the iron foundry has been the increasing knowledge and use of alloying elements,



175 kw.–500 lb. electric rocking furnace, installed for the production of Ni-resist castings.

but this subject has been so frequently discussed in its many aspects in technical literature that it will be sufficient to summarise the main points. The advantages of alloy irons are felt to their greatest extent when wear or heat-resisting properties are sought, or when a dense product capable of taking a high surface finish is desired. The use of molybdenum and the joint addition of small proportions of nickel and chromium are known to confer exceptional wear-resisting properties. Austenitic irons containing appreciable quantities of nickel, copper and chromium, such as Ni-resist, or nickel, silicon and chromium, such as Nicrosilal, possess remarkable heat-resisting properties and have filled the gap between the common irons and the cast Ni-Cr-Fe alloys. High chromium irons containing in the region of 28% Cr, are finding favour for scale resistance when conditions are such that the parts are not stressed. There are other compositions too numerous to enumerate, which include nitriding irons, non-magnetic irons, and a variety of heat-treatable compositions.

These developments which have taken place in the cast iron industry have emphasised the need for close

1 J. E. Johnson, Junr., "The Principles, Operation and Products of the Blast Furnace." (McGraw-Hill.)

control over composition and melting conditions, and it is in this direction that the electric furnace has materially assisted these advances in the cast-iron foundry.

Cupola Melting.

The cupola, like most shaft furnaces, is an efficient appliance and a cursory examination of the problem would appear to rule out electricity as being too expensive a heating medium. On the other hand, there are many foundries employing electric melting which are showing a saving in operating costs over cupola practice, and at the same time producing high duty irons with extreme precision.

In the cupola it is practically impossible to produce a low carbon superheated iron with any certainty or regularity. If steel scrap is added to the burden, the blast must be increased to raise the temperature, thus promoting oxidation. The higher temperature will cause the iron to pick up more carbon when trickling over the incandescent coke and absorption of carbon in excess of a limiting amount will induce coarse graphitisation and defeat the effects of superheating. Another shortcoming of the cupola is that there is a sulphur pick-up from the coke and the foundry returns may show a sulphur content of ·02–·04% above that of the materials charged. It is therefore evident that the raw materials must be lower in sulphur than the specification in order to counterbalance the pick-up in the cupola as well as the increased sulphur content of remelted sprues, etc. Without some form of briquetting treatment, light scrap such as swarf and borings cannot be utilised in the cupola without excessive loss, whilst there is a tendency to blowing out of the stack. The economy of the electric furnace depends to a large extent upon its ability to use cheap light scrap, such as steel punchings, sheet clippings, swarf, and cast-iron borings, with a minimum metallic loss and at the same time it can produce from these raw materials an iron superior to the cupola product. Experience with electric melting has proved that the use of special brands of pig iron, formerly held to be essential for the revivication of foundry scrap, is an outworn tradition. The use of a proportion of mild steel scrap serves the purpose of lowering, by dilution, the phosphorus, sulphur, and carbon content of the melt, and it is further to be recommended as it rapidly absorbs graphite nuclei thus promoting graphite refinement. In point of fact, much of the high-test iron now being poured is made exclusively from steel charges carburised with petroleum coke or crushed electrodes. The carbon is located low down in the charge so that it will be "taken up" by the molten metal as it trickles downwards. It is advisable to add the silicon, as ferro-silicon, after recarburising is complete, since carbon absorption is more rapid in the absence of silicon. The "efficiency" of carbon pick-up is constant with standardised melting practice and generally lies between 70% and 80%. As a specific example, one firm obtained, by the addition of 58 lbs. of crushed coke to 2,000 lbs. of steel punchings, analyses within the limits of 2·18% and 2·24% C. over 200 separate heats.[2] It should be stated that agitation of the metal improves considerably the efficiency of recarburisation. Many foundries run entirely without pig iron, purchasing mild steel turnings and cast-iron borings as raw material, and the losses sustained when melting all scrap charges of this nature rarely exceed 2%. It must be remembered that this is not all oxidation loss and includes dirt and oxide entrained with the charge. Heavier charges rarely show a melting loss exceeding 1%. When charges consisting of a large proportion of light scrap are melted, the whole complement of the charge can rarely be accommodated in one feed, and a subsequent charging operation is necessary after the initial feed has formed a pool. It is often found that when light scrap is melted the power consumption is lower than for heavier scrap, due to the rapidity of melting owing to the large surface area exposed to the intense radiation from the arc.

2 C. R. Culling. Paper before Amer. Foundrymen's Assoc., June, 1933.

Some Features of Electric Melting.

A further feature of this system of melting is that the atmosphere can readily be maintained, reducing in character, with the result that there is no loss of expensive alloying elements, whilst the resulting composition of the metal is the arithmetic sum of the analyses of the materials charged. With the increasing use of alloying elements this factor is one of considerable moment. It is reported by Culling[3] that repeated remelting of Ni-resist, returns and sprues, showed no change in composition. Alloys which oxidise preferentially to iron, such as chromium, vanadium, silicon and manganese, can be charged at the beginning of a heat with the certainty that practically no loss will occur. The ability to charge initially these alloys as well as the less oxidisable additions, such as nickel and copper, undoubtedly improves their effectiveness, due to complete assimilation and uniform distribution throughout the melt. It is common knowledge that ladle additions in cupola practice are not satisfactory on account of chilling, incomplete solution, and segregation of the elements. In the cupola readily oxidisable alloys, such as chromium, would be partially or completely lost, whilst additions of nickel may be held up in the shaft making it impossible to obtain a predicted analysis.

The electric furnace has gained favour in foundry practice because of its ability to reproduce both melting conditions and analyses. It is often claimed that its use will result in a better deoxidised and degasified product. The effect of dissolved gases on cast iron is an unknown factor about which there is little collected knowledge. As regards oxygen, it is impossible to conceive of a molten cast iron holding any proportion of this element in an uncombined state. An iron, containing as it does appreciable proportions of silicon and manganese, cannot dissolve more than the merest trace of oxygen. By consulting M'Cance's curves[4] it will be evident that the percentage deoxidation (that is, of the saturation value of oxygen in iron) is in the region of 99%. Any oxygen that has come into contact with the charge will immediately assume the form of $MnO\text{-}SiO_2$ complexes and it is the removal of these inclusions which will improve the fluidity and density of the iron as produced in the electric furnace. Clarification from inclusions is materially aided by a high temperature, which increases fluidity, whilst stirring of the melt will assist coagulation and the elimination of non-metallic particles to form a slag. It should be stated that in electric melting practice the atmosphere is such that there is no necessity to employ a protective slag on the bath. Normally a small pool of slag is formed in the middle of the bath, emanating from the dirt and sand on the scrap. As this foreign matter is invariably of a siliceous nature, the refractories employed are generally acid or neutral in character.

A problem which often arises in the jobbing foundry under present-day conditions, when piecemeal orders are more common than repetition work, is that of producing several special analyses each incurring only a small weight of charge. It is possible to do this in a single heat in the electric furnace. A charge of base metal is first built up to a certain composition. The portion required of this analysis is then cast and the remainder is adjusted by the addition of steel scrap if the carbon has to be lowered, or the metal diluted in silicon or manganese; and by charging coke and ferro-silicon if the carbon and silicon contents have to be raised. As many as six different compositions are often poured from one heat. Moreover, owing to the facility of raising quickly the temperature or cooling by chilling with scrap, different casting temperatures can be readily obtained if desired. The advantage of this system for ensuring quick deliveries and economic operation is apparent.

The electric furnace is undoubtedly the most rapid melting appliance known to the foundryman, and this

3 loc. cit.
4 Trans. Farad. Soc., December, 1925.

feature in itself is often of considerable importance. A quick succession of comparatively small charges requires less floor space for the melting plant and a reduced area for mould set-up—giving an approach to a practically continuous flow of molten metal. Some furnaces are so rated that they will melt their holding capacity in 50–60 minutes. The casting temperature is under ready control and it can be accurately estimated for duplicate charges from the kilowatt-hour meter reading. Under similar conditions the charge will absorb the same amount af energy to bring it to a certain pouring temperature.

Duplexing.

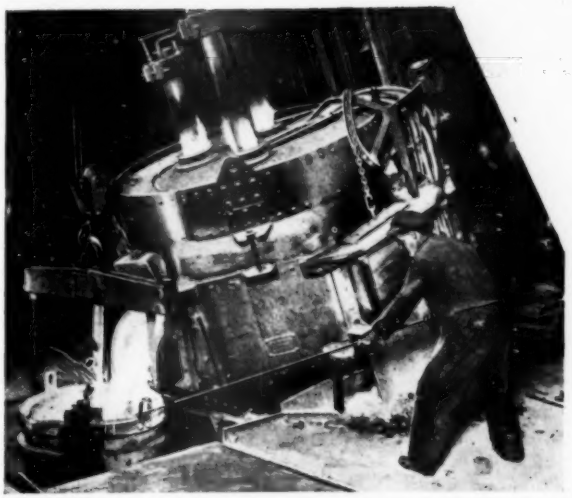
The use of duplexing is often advantageous for the mass production of repetition castings, and for the rapid handling of large orders required for immediate delivery. In this case the cupola is employed to feed molten metal to the arc furnace. The metal charged is adjusted in composition, alloy additions made if required, and superheated in the electric furnace. The productive capacity of this latter equipment by this method of working will be increased five-fold, whilst the properties of the resulting castings can be made superior to those produced by the cupola. In certain instances the electric furnace is mounted on a scale, and the molten additions from the cupola weighed as they are charged. Duplexing has not always found favour owing to the difficulty of synchronising operations and handling quickly large quantities of molten metal, but these disadvantages are more apparent than real. The metal is generally transferred from a cupola by means of a ladle or by way of launders. Duplex working often results in saving in operating costs, since the power consumed for superheating and reconditioning the charge is only of the order of 90–100 kw. hrs. per ton, as against approximately 600 kw. hrs. for cold melting and superheating. It is frequently advisable to add a proportion of light mild steel scrap in the electric furnace to lower the carbon, sulphur, or phosphorus content. A 2-cwt. addition will raise the consumption for superheating to 150 kw. hrs. per ton. Some average operating costs for cold melting and duplexing practice are tabulated below. It will be appreciated that these costs will vary considerably with operating conditions, the availability of raw material, and the prices ruling in different localities. They are only cited here as being generally representative of average working.

ELECTRIC ARC FURNACE COSTS FOR COLD MELTING PRACTICE.
(Output, 4½ tons per 9-hour day).

	£	s.	d.
Energy, 610 kw. hrs., @ 5d.	1	5	10
Labour, 2 man-hours	0	4	0
Electrodes, 7½ lbs. graphite, @ 1s.	0	7	6
Refractories, material and labour	0	4	6
Maintenance, water, etc.	0	1	6
Interest and amortisation	0	2	6
Metal loss, 1½%	0	1	3
Raw materials—			
5 cwt. foundry scrap, @ 3s.	0	15	0
5 ,, M.S. turnings	0	8	0
10 ,, cast-iron borings	0	15	0
Recarburisers and ferro-alloys	0	3	0
Cost of metal per ton in ladle	4	8	1

COST OF DUPLEXING IN THE ELECTRIC ARC FURNACE.
(4 tons/hr., superheating 200° C.)

	£	s.	d.
Power, 150 units, @ 5d.	0	6	3
Electrodes, 2 lbs., @ 1s.	0	2	0
Labour	0	1	0
Refractories and maintenance	0	2	6
Ferro-alloys, etc.	0	1	9
	£0	13	6
Deductions:			
Difference between cost of cupola metal and 2 cwts. of steel turnings = 8s. less 3s. 3d. £0 4 9			
Allowance for cheaper raw material used in cupola, per ton £0 3 0	0	7	9
Nett cost of duplexing per ton	0	5	9



Direct series-arc furnace as used for cast iron melting—showing a furnace pouring into a ladle.

It will be noted that the cost of duplexing does not add itself to the price of cupola metal at the spout, as cheaper raw materials can be charged into the cupola, whilst the coke to charge ratio can be cut down. The addition of a proportion of mild steel scrap, as has been stated, serves the dual purpose of reducing the carbon and sulphur contents, and inducing graphite refinement.

Appreciation of Arc Furnaces to Malleable Cast Iron Practice.

Before concluding, it will be interesting to review the progress in the application of the arc furnace to black-heart malleable iron practice—especially in the development of short-cycle malleable irons. It will be recalled that one of the first applications of the electric furnace in the iron foundry was for malleable iron and it took the form of what was known as the Kranz triplex process. This has been described in detail by Schwartz.[5] The electric furnace in this case only served as the receptacle for the molten metal in its final stage for superheating the low carbon iron to about 1,600° C. and for ensuring constancy of composition. Much research has been instituted in America with a view to reducing the time expended in the malleablising treatment. This not only diminishes the time required for processing and hastening deliveries, but results in substantial economies in fuel consumption. Efforts have been made to reduce this time by the elimination of packing materials by the adoption of electric heating and controlled atmospheres. Further savings in time are possible by regulating the first soaking period (well above A_{c1}) which breaks down the massive cementite, and then cooling rapidly to just below the eutectoid temperature for destroying the pearlite. An interesting research conducted by White and Schneidewind[6] has brought to light the fact that an increased degree of superheat curtails considerably the time required for the malleablising treatment. By raising the molten metal temperature from 1,538° C. to 1,720° C., the time, they found, could be cut down by 60%. The use of superheat permits of raising, within limits, the silicon content of the iron (which increases the speed of graphitising) without incurring the danger of primary graphite separation after solidification. A typical composition of a superheated short-cycle malleable iron which can be used for sections up to ½ in. thick is quoted by Morken[7] and is given below:

	%
C	2·4
Si	1·65
S	·05
P	·05
Mn	·25

5 H. A. Schwartz, "American Malleable Cast-Iron." (Penton Pub. Co.)
6 Preprint No. 33-12. Amer. Foundrymen's Assoc., June, 1933.
7 Amer. Soc. for Steel Treating, October, 1933.

The annealing cycle for charges ranging up to five tons in weight was as follows :—

Heat to 954° C. in 3 hours
Soak at 954° C. for 4 hours
Cool to 677° C. in 14 hours

The resulting physical properties of this material were :

Tensile strength	26.8 tons/sq. in.
Yield point	17.8 "
Elongation on 2 in.	15%
Impact test (Charpy)	7 ft. lbs.
Brinell Hardness No.	150

It will be realised that the treatment of these white irons, after decomposition of the massive cementite constituent, can be considerably varied to give matrices consisting of martensite, sorbite, pearlite or ferrite, the latter being usual in the long-cycle process. The strength of these irons can be considerably increased by modification of the state of the eutectoid carbide, but the higher strength material is only obtained at the expense of ductility. For simple castings requiring a high tensile figure, the following treatment has been successful. Soaking for 3–4 hours at 950° C., air cooling to 760° C., then oil quenching followed by "drawing" at 732° C. for 1 hour, and subsequently air cooling for handling. This product gives an ultimate stress of from 40–55 tons/sq. in. and an elongation of 3–6%, whilst the modulus of elasticity exceeds 30,000,000. This material is finding a wide application for camshafts, and is said to possess exceptional stress damping properties. When a softer pearlitic matrix is required, the iron may be held at about 815°C. (following an air quench from 950° C.) after which air cooling is employed. The tensile strength of this material will be approximately 34 tons/sq. in. with an elongation of 9%. These properties are admittedly remarkable considering the short time of treatment and there seems little reason why developments on analagous lines should not be made in this country with white heart malleable.

There is still a prevailing prejudice among engineers against the use of cast irons for stressed members, but the fact that they are becoming increasingly employed in the automobile industry for such parts as camshafts, tappets, manifolds, brake drums, and even crankshafts, is an indication of the growing appreciation of this relatively new material of construction—high duty cast iron. The cupola will have its place in the foundry for some time yet producing the ordinary grades of grey iron, but the electric furnace must grow in importance since it can melt high duty irons with regularity and uniformity and at a cost comparable with that of cupola practice.

MOLYBDENUM IRON ROLLS*

THE use of molybdenum in iron rolls in America is quite as common as its use in steel rolls, according to Bradley's Magazine. Its use has grown, not only in rolls for use in steel mills, but has been extended to the brass, copper, bronze, or non-ferrous industry, and even to application in paper pulp mills. The effect of molybdenum has proved beneficial to both the chilled iron roll and the sand or grain roll. It has been found that the introduction of this element produces a stronger roll; reduces breakages of rolls in services; gives greater resistance to wear; and enables the production of a smoother and better finish on rolled products.

Iron rolls do not generally receive any heat treatment. It is necessary, therefore, to conduct the casting operation with care, regulating the chill or hardness in accordance with usual practice and not subject the iron roll to subsequent heat treatments.

If for any reason molybdenum alloyed rolls are desired only in the annealed state, a double annealing is carried out first at 1,650 to 1,800° F. (900 to 985° C.) and then at 1,475 to 1,550° F. (800 to 850° C.). The first annealing cycle reduces any danger due to dendritic crystallization by breaking up this undesirable texture, while the second annealing operation refines the grain; in both phases molybdenum plays an important role by reducing any discrepancies caused by non-homogeneous structures. In general, it is good practice to subject any roll containing molybdenum nickel and chrome to a treatment similar to the one indicated, regardless of the subsequent thermal operations.

THE COMPOSITION OF MODERN ROLL METALS.

	T.C. %	C.C. %	Si. %	Mn. %	S. %	Ph. %	Ni. %	Cr. %	Mo. %	V. %	W. %
1. AMERICAN CHILLED ROLLS.											
Light Rolls	3·23	—	0·84	0·49	0·073	0·418	—	—	—	—	—
Light Rolls	2·91	—	0·74	0·33	0·058	0·380	—	—	—	—	—
Heavy Rolls	2·77	—	0·56	0·88	0·112	—	—	—	—	—	—
Heavy Rolls	2·49	—	0·60	0·27	0·096	—	—	—	—	—	—
2. EUROPEAN CHILLED ROLLS.											
Light Rolls	2·89	—	0·90	1·01	0·090	0·440	—	—	—	—	—
Heavy Rolls	2·59	2·23	0·63	0·36	0·084	0·312	—	—	—	—	—
Heavy Rolls	2·39	2·12	0·54	0·28	0·070	0·096	—	—	—	—	—
3. SEAMLESS TUBE ROLLS (Pilger).											
American Roll	0·74	—	0·37	0·88	0·017	0·32	0·38	1·48	—	—	1·43
European Roll	0·92	—	0·41	0·93	0·014	0·039	0·12	1·19	—	—	1·22
4. ROUGHING ROLLS (Billets and Bars).											
60–200 ft. min. (1)	1·16	—	0·33	0·79	0·028	0·32	2·47	0·59	—	—	—
60–200 ft. min. (2)	1·37	—	0·42	0·94	0·034	0·026	1·84	0·71	0·34	—	—
60–200 ft. min. (3)	1·20	—	0·31	0·73	0·032	0·047	2·04	0·63	—	—	—
60–200 ft. min. (4)	0·93	—	0·26	0·87	0·042	0·051	0·91	0·67	0·24	—	—
5. ROUGHING ROLLS.											
200–500 ft. min. (1)	1·61	—	0·36	0·93	0·038	0·042	0·31	0·98	0·31	—	—
200–500 ft. min. (2)	1·72	—	0·58	0·43	0·041	0·052	1·74	0·77	—	0·11	—
200–500 ft. min. (3)	1·68	—	0·71	0·31	0·084	0·144	1·59	0·88	—	—	—
200–500 ft. min. (4)	1·58	—	0·30	1·06	0·044	0·058	0·18	1·22	0·24	—	—
6. ROUGHING ROLLS.											
500–800 ft. min. (1)	1·86	—	0·62	0·34	0·067	0·096	1·67	0·91	—	—	—
500–800 ft. min. (2)	1·63	—	0·53	0·65	0·032	0·056	0·82	1·21	—	0·08	—
500–800 ft. min. (3)	2·11	—	0·78	0·40	0·036	0·047	0·23	1·09	0·19	—	—
500–800 ft. min. (4)	1·93	—	0·74	0·38	0·081	0·128	1·77	0·79	—	—	0·43
500–800 ft. min. (5)	1·86	—	0·60	0·35	0·089	0·112	1·61	0·94	0·28	—	—
7. LARGE ROUGH ROLL	0·52	—	0·36	0·67	0·014	0·019	0·27	0·58	—	—	—
8. ROD MILL AND SMALL SECTION ROLLS.											
800 ft. min. (1)	2·18	—	0·61	0·38	0·096	0·128	1·44	0·91	—	—	—
800 ft. min. (2)	2·43	—	0·46	0·42	0·028	0·048	0·27	1·32	0·26	—	—
800 ft. min. (3)	2·51	—	0·76	0·31	0·081	0·140	0·65	1·09	—	—	—
9. CHILLED HIGH CARBON.											
Also suitable for Rod Mills	3·64	—	1·51	0·83	0·023	0·079	1·01	1·38	0·27	—	—
10. ROLL FOR ROLLING ALLOY STEEL	3·31	—	1·38	0·88	0·026	0·074	1·22	1·40	—	—	—

* By Courtesy of the Editor of "Bradley's Magazine."

Developments in Soviet Russia

By a Russian Correspondent

Russia is rapidly becoming industrialised, and her workers are now able to manufacture not only the heaviest machinery for power stations, but also delicate and specialised scientific equipment. In this article a brief report is given of progress achieved and contemplated.

WHATEVER opinions are held regarding the development of the Soviet industries, it must be acknowledged that remarkable progress has been achieved in a relatively short time. Russia is now able to produce on a scale considered to be impossible only a few years ago.

It is true that she has experienced many difficulties, but what country, whose people were primarily concerned with agricultural pursuits, could hope to transform to industrial production on such a gigantic scale without difficulties of a colossal character? Even those countries that are highly industrialised are faced with problems that baffle their greatest experts; yet the U.S.S.R. has developed a plan which must have an international significance of great importance, particularly the fact that unemployment is non-existent, and poverty in the villages has been abolished.

That the country has been transformed is evident from the report of Mr. Kuikbyshev, Vice-President of the People's Commissars of the U.S.S.R., given at the Third Congress of Soviets of the Moscow Province. He dealt with the development of the national economy scheme during the four years from the Sixth All-Union Congress of Soviets to the Seventh Congress, which has just been held. Some of the points stressed by Mr. Kuibyshev in his report indicate the extent of progress, and a brief reference to these will show they are noteworthy.

The gross output of large-scale industry in the U.S.S.R. has increased in value from 27 milliard roubles in 1930 to 50 milliard roubles in 1934, roughly about 80%. Capital investments in the socialised section of the scheme, which in 1930 amounted to 9.8 milliard roubles, was increased to 22·6 milliard roubles in 1934. The number of workers embraced by the scheme has increased from 14·5 million in 1930 to 29·2 million in 1934. The average annual wage of all workers has risen from 936 roubles in 1930 to 1,782 roubles in 1934—roughly 90%. The State budget has grown from 11·2 milliard roubles in 1930 to 49·9 milliard roubles in 1934.

It must be remembered that this large-scale development has taken place at a time when the industrial world has experienced a depression of unparalleled severity. The growth of industrial production in relation to the Second Five-Year Plan, is given in greater detail in the accompanying table, which gives the production estimated in that Plan, and the percentage of fulfilment from the latest returns:

A general view of the blast-furnace plant at the Stalinsk Metallurgical Works, Siberia.

Capital Investment and Principal Plants.

A sum of 39·2 milliard roubles was invested in industry between the years 1930 and 1934, and 30·2 milliard roubles was allocated as working capital. A large proportion of these amounts pertain to the years 1933 and 1934, years of the Second Five-Year Plan. During these years the following industrial enterprises begun under the First Five-Year Plan, were put into operation:

Machine-building plants.—The Ural and Kramatorsk Heavy Machine Building Plants, and Lugansk Locomotive

Building Plant, the Ural Car-Building Plant (the first shops), the Kharkov Drill-Press Plant, the Cheliabinsk Tractor Plant, the Cheliabinsk Abrasive Plant, etc.

Electric power stations.—The Stalinogorsk (first section), the Dubrov, Svir No. 3, Rion, Niva, Dzorages power stations the Kadyrya Station, the station of the Thermo-Technical Institute, the Krasnozavodsk station, the Kizel station (third section), the Kemerova station (first section), the Voronezh Station, etc.

Metallurgical plants.—The blast furnace shops in the Zaporozhe plant, in Azovstal; the Krivoi Rog, Lipetsk, Zestafon ferro-manganese, Zaporozhe ferrous alloys, Zaporozhe instrumental steel plants, etc.; in the Magnitogorsk and Kuznetsk plants construction is so far advanced that this year there will be completed the first sections of these plants with a complete cycle of production—pig-iron, steel, rolled iron; in the non-ferrous section the plants put into operation include the first section of the Pyshmen Plant for the electrolysis of copper, the Orjonikidze Electrolytic Zinc Plant, the Chimkent Lead Plant, the Ufa Nickel Plant, the Dnieper Aluminium Combine, and several others of minor importance.

Industries.	Unit of measurement.	1930.	1934.	1934. Production estimated by five-year plan.	1934. percentage of fulfilment.
Gross output of the whole of industry	In milliard roubles at 1926/27 prices	30·2	53·9	55·8	96·6
Including—					
Heavy industries	,,	—	30·5	30·9	98·7
Light industries	,,	—	23·4	24·9	93·9
Gross output of large-scale industry	,,	27·5	49·5	50·8	97·4
Metal manufactures	,,	4·8	13·4	12·6	106·3
Output of electric energy	In milliard kwt. hours.	8·4	20·5	19·0	107·9
Output of coal	Million tons	48·8	93·5	96·2	97·2
Output of oil	,,	18·8	25·5	28·7	88·9
Output of pig iron	,,	5·0	10·4	10·0	105·4
Steel	,,	5·9	9·6	9·8	98·1
Rolled steel	,,	4·6	6·7	6·6	101·8
Chemical industry	Million roubles	—	2,208	2,044	108·0

Considerable development has been expected in other basic industries, thus, in the coal industry 69 mines were put into operation with an aggregate capacity of 33·7 million tons; in the oil industry the Saratov cracking plant, the petroleum gas plant No. 1, and others were erected; while in the chemical industry, the Khibinogorsk Apatite Combine, the Voskresensk and Stalingorsk chemical combines, the Solikamsk Potassium Combine, as well as smaller works, were formed. In addition, building work has been commenced during the first two years of the Second Five Year Plan on such enterprises as the power stations in Yaroslavl, Perm, Chirchik, the second Svir station, the Khram, Terter, Orsk, Kiev (second unit), Tkvarcheli stations; in the coal mining industry, 25 mines with a capacity of 8·7 million tons; six pipe still units, four cracking plants, and 14 coke still batteries in the oil industry; three shale mines with a capacity of 1·32 million tons; included in these there is the Khalilov Metallurgical Combine, the Nikopol Piping Plant, the Blyavin combine, the Kolbaolovo plant, the Dnieper magnesium plant, the Urals aluminium combine, the Urals bauzite mines, and the Tikhvin aluminium combine. Machine construction plants in progress include the Dniepropetrovsk Carborundum plant, the Ryazan Electric-Lamp Plant, and extension work on the Gorki, Stalin and Yaroslavl automobile plants; while development of the chemical industry is proceeding by the construction of the Gorlovka nitrogen products plant (second unit), the Cheliabinsk nitrogen products plant, the Karabugaz Chemical Plant, the Kemerovo nitrogen fertiliser combine, and the Erivan plant.

Ferrous and Non-Ferrous Metal Production.

The production of ferro-alloys has been increased four-fold from 1930 to 1934, while the process of producing ferro-manganese in electric furnaces has now been achieved; the production of electric steel has advanced to such an extent that the U.S.S.R. claims to hold first place in Europe in actual volume produced. At the beginning of the Second Five-Year Plan, only copper, lead and zinc were produced in the U.S.S.R., and the production of aluminium had just commenced. By the end of 1934 the aluminium industry had been transformed into a powerful branch of production, nickel was produced, and the latest production methods and processes, both in the new and old branches of industry had been mastered.

The iron and steel industry had made great advances in the mechanisation of production, and there is no doubt that these advances have constituted an important factor in the general progress achieved. The proportion of pig-iron smelted in fully mechanised furnaces was doubled in 1934, as compared with 1930, and amounted to 47·2% of the total iron smelted.

Mr. Kuibyshev pointed out that while notable successes have been achieved in the production of steel, the various forms in which it is used still lag behind those of iron. In the future, he states, this situation must be remedied, as the iron and steel industry does not meet the demand for steel in its many forms. More attention is to be given to production, particularly in improvements associated with the open-hearth and rolling-mill departments, and in the training of competent workers. Mr. Kuibyshev also stressed the necessity of speeding-up production in the copper industry. In 1931, 1932, and 1933 production remained stationary, but in 1934, as a result of changes in the organisation of the industry, and an increase in technical knowledge, the output of pitch copper increased by 18·1%. The problem, however, is to secure an increase in copper output of 35·9% in 1935, and to achieve this result special attention is to be given to the ore-concentration industry, to ensure that the concentration and copper-smelting plants always have on hand adequate supplies of ores; improvement of technical work of the copper-smelting plants is also contemplated.

Heat and Sound Insulation.

ONE of the latest and most useful heat and sound insulating mediums was the subject of a paper read before a recent joint meeting of the Glasgow Sections of the Society of Chemical Industry and Institute of Chemistry in Glasgow. The paper was by Mr. J. Boyd, B.Sc., and dealt with the manufacture and applications of "Glass Silk." The problem of heat insulation has received considerable attention in recent times, and its importance is now being more appreciated. The use of glass silk, explained Mr. Boyd, originated in Germany during the Great War, and its manufacture in Great Britain was commenced in Glasgow at the end of 1930. As an insulating medium it had made steady progress. It could be stated that the new industry was capable of meeting the most stringent requirements of modern steam and heat engineering generally.

Glass silk is made by heating glass until it is molten, forcing it through small apertures and whisking over the minute threads thus formed to a rotating drum. The "silk" at this stage consists of a mass of fibres, which are later spread on tables in the form of thin veils, one on top of the other until the requisite thickness is obtained. The finished product is in the form of large mattresses suitable for covering extensive areas, and in strips for covering small diameter pipes. It has low specific gravity; stands up to high temperatures—having shown no signs of disintegration at 1,000° F.; is quite unaffected by severe vibrations, or alternations of temperature; is immune from acid and rodent attack; and its thermal conductivity at a mean insulation temperature of 55° F. is C.27 B.Th.U's per square foot per hour for 1 in. thickness and 1° F. difference in temperature. Mr. Boyd gave numerous examples of the uses to which the material is being put. He explained also that glass silk is being used in many ways as a sound insulator, examples being its extensive use in building construction and in silencers for cars and motor-cycles.

Sodium Carbonate in Iron and Steel Works

Granular sodium carbonate is a dust-free product and is adapted to most of the demands of the iron and steel industries, but for certain purposes it is fused and cast in blocks. The subject was discussed by Mr. N. L. Evans, before a recent meeting of the Edinburgh Branch of the Institute of British Foundrymen, and part of the information he gave is given in this article.

SODIUM carbonate melts at 851°C. and does not volatilise too rapidly until it is heated to 1,450° C. or even higher. It therefore has a useful range of about 600° C., when used as a flux, within limits which include copper, brass, bronze and cast-iron melting. When molten it is very fluid, and decomposes, resulting in the formation of carbon dioxide gas. It forms a basic slag and is therefore capable of desulphurising metals. In conjunction with sodium carbonate ground limestone is frequently required; this should be finely ground and as free as possible from silicon and sulphur compounds and carbonaceous matter.

Chemical Reactions.

The chemical reactions of the sodium carbonate process are probably very complicated, and, as in the case of the heat reactions, it is impossible with any degree of certainty, to give a complete series of equations. It can be said definitely, however, that part of the sulphur from the metal is retained in the slag, and part of it is evolved as sulphur dioxide, which can invariably be detected by smell during the course of the process.

The following equations probably represent the principal reactions :— (Fig. 6).

(1) $Na_2CO_3 + \frac{MnS}{FeS} = Na_2S + \frac{MnO}{FeO} + CO_2$

(2) $Na_2S + MnO + FeO + Na_2CO_3 = 2Na_2O + Mn + Fe + SO_2 + CO$

(3) $Na_2CO_3 = Na_2O + CO_2$

(4) $Na_2S + SiO_2 + \frac{MnO}{FeO} = Na_2O.SiO_2 + \frac{MnS}{FeS}$

(1) Is the main desulphurising reaction, resulting in the formation of sodium sulphide which can be detected in the slag.

(2) Explains why the manganese content of treated metal is often higher than that of the same metal before treatment. Manganese sulphide which would normally float to the surface of the bath, and be lost as slag, is reduced to metallic manganese which goes back into the melt.

(3) Is the simple dissociation of sodium carbonate which is responsible for the evolution of carbon-dioxide and the agitation of the melt.

(4) Illustrates the harmful action of silica, which reacts to form sodium silicate and re-forms manganese sulphide or iron sulphide. This silica may have its origin in cupola slag which is allowed to escape, old slag adhering to the ladle sides, or attack on the refractory lining.

Sulphur Removal.

Some actual examples of the amount of sulphur removed when sodium carbonate alone is put in the bottom of the ladle, and the slag so formed is subsequently thickened with ground limestone, showed the sulphur reduction to vary from about 30% to nearly 60%. Even greater reductions have frequently been obtained when contact between metal and slag has been prolonged, but the author stated the figures quoted could be taken as average results.

Cupola treatment has been found to give very satisfactory results in the case of malleable iron, the types of unsoundness to which white iron is susceptible being reduced to a marked extent.

For Blackheart malleable, however, the best results are obtained by making a desulphurised pig iron which can be treated in a ladle or receiver, as it is essential in this process to have a much lower sulphur content than is usual in Whiteheart malleable iron. In America where it is usual to melt in an air furnace for Blackheart malleable, a sodium carbonate slag is formed in the furnace, and it is claimed that, in addition to controlling sulphur, it shows a saving in fuel as it speeds up slag separation from the melt.

SULPHUR REDUCTION.

Typical results, using separate additions of Sodium Carbonate and Ground Limestone.

Untreated.	Treated.	Sulphur Reduction.
% S.	% S.	%.
0·13	0·062	52
0·08	0·05	37
0·104	0·048	54
0·091	0·063	31
0·10	0·043	57
0·076	0·040	47

SULPHUR REDUCTION.

Typical results, using a mixture of Sodium Carbonate and Ground Limestone.

Untreated.	Treated.	Sulphur Reduction.
% S.	% S.	%.
0·144	0·096	33
0·116	0·078	33
0·106	0·087	18
0·10	0·055	45
0·11	0·085	23
0·072	0·053	26
0·136	0·077	43

In the manufacture of steel castings by the Tropenas process, the production of a metal low in sulphur is essential, and a method by which that element can be removed not only improves the quality of the castings, but effects considerable economies by giving a much wider choice of raw materials. Mixtures containing high percentages of scrap are being successfully melted and converted to steel, and the quality of the resulting castings is not in any way sacrificed.

In the Bessemer steel process, whether acid or basic, the use of sodium carbonate offers a ready means of reducing the sulphur, by treating iron in the ladle in which it is transferred from the blast furnace or mixer to the Bessemer converter. If siliceous slag is kept out of the ladles, the process is very efficient with such a large bulk of metal. The same remarks apply to the manufacture of basic open-hearth steel, when liquid metal is charged to the furnace.

Catalytic Action of Sodium Carbonate.

There are two catalytic effects of sodium carbonate which are of interest to the iron and steel industries, although they do not yet appear to have been developed on a commercial scale.

The first is the effect noticed by Williams and Ragatz, that sodium carbonate accelerates the rate of reduction

of iron ores. This might find application in the blast furnace, or in some of the processes now in course of development for the low-temperature reduction of iron ore to form sponge iron. At the present time definite interest is being shown in sponge-iron processes, owing to the difficulty of obtaining sufficient supplies of suitable scrap for steel-making. Whether any such process could compete with the blast furnace on a cost basis is still open to doubt. One disadvantage of sponge iron from the point of view of the steel maker, is its high sulphur content, usually about 0·2%. Sodium carbonate might be of use in dealing with this.

It should be mentioned, in connection with the work of Williams and Ragatz, that it has since been proved that the sodium carbonate has no direct action on the iron ore, but it increases the reactivity of the coke. One possible means of applying it would, therefore, be to quench the coke in a strong solution of sodium carbonate, so that it would be thoroughly impregnated.

The second effect, described by Professor Cobb in this country, and by other workers in America, is the acceleration of the rate of decomposition of steam by carbon, and the rate of reduction of carbon dioxide by carbon. In making producer gas, the capacity of a producer might be increased if sodium carbonate were used, owing to the shorter contact time required; and the gas should contain less undecomposed steam and carbon dioxide, and more carbon monoxide and hydrogen.

Non-Ferrous Metals.

The fluxes used in non-ferrous melting have been shrouded in the deepest mystery, and very little scientific basis appeared to exist for their application. But a recent paper by Tyrie* has shed a considerable amount of light on this subject, particularly regarding the melting of brass and bronze swarf. Tyrie points out that deoxidation of such materials is usually necessary, and the oxides formed as a result of this need to be removed. The speed of their separation from the metal bath is dependent on their particle size, large particles floating to the surface easily. It is desirable, therefore, to add a flux which will combine with, or dissolve the small oxide particles, and by increasing their size, carry them up to the surface. Sodium carbonate appears to be one of the most useful substances for this purpose, as it melts readily (at 851° C.), forms a fluid slag, and is not unduly volatile at the melting temperature of brass and bronze.

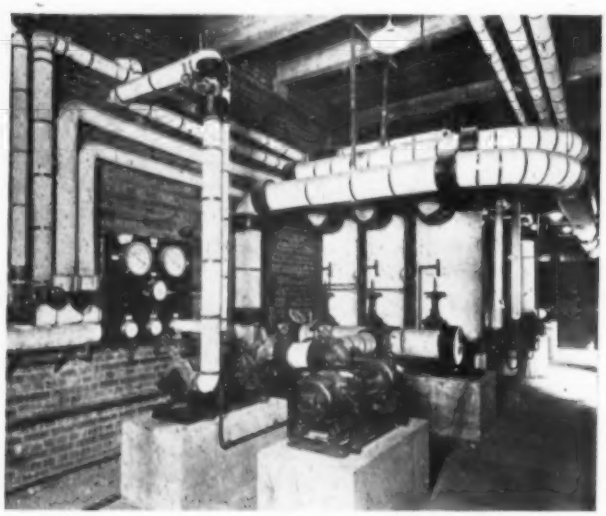
It will be seen that the principle underlying this is the same as that whereby oxides, silicates and sulphides are removed from cast iron.

* Chemical Age, Vol. XXX, No. 762, pp. 9–11 (3/2/34).

Steam Boiler and Pipe Coverings

In heat insulation, magnesia takes a high place because of its cellular structure, and is claimed to effect considerable economy.

BOTH in the iron and steel and the colliery industries, efficient covering of steam pipes and boilers is a matter of primary importance, although often neglected to a degree much worse than in the average industrial establishment. In this connection, 85% magnesia has strong claims to be considered the ideal material since it fulfils the rather varied requirements in striking fashion. The first point to be considered in connection with coverings



Installation of steam pipes and calorifiers with 85% magnesia sectional and plastic coverings.

is of course, the efficiency of heat insulation, and magnesia takes a high place in this direction, because of its cellular structure. Thus some detailed tests that have been carried out at the National Physical Laboratory (Teddington) show that "Darlington" magnesia effects an average saving of about 90 to 95% of the total heat that would be radiated to the air from a bare steam pipe.

It should be stated also that the Chemical and Insulating Co., Ltd., of Darlington, who supply these coverings, manufacture the magnesia in their own works, direct from the local Dolomite or calcium magnesium limestone, by the well-known "Pattinson" process, involving "burning" in kilns, slaking and separation of the lime from the magnesia, primarily by the use of carbon dioxide gas. The magnesia (magnesium carbonate) so obtained is chemically pure and snow-white in colour, while also being in the form of microscopic light and feathery crystals, with all the interstices or cells between filled with air.

The product is mixed with 15% long fibre asbestos to give a binding effect, and the firm specialise not only upon the production of the magnesia in powder form, but also as moulded sections and slabs ready for immediate application to pipes, boilers, engines, turbines, and other equipment.

Important also, is it that the material used for covering should not deteriorate by constant contact with the hot steam pipe or other surface. In this connection magnesia will stand a temperature up to about 650° F. for years without any disintegration. Further, if very high superheated steam is being used, say from 650 to 1,000° F. then the firm supply a special product known as "Dextramite," which is first put upon the pipe and then the 85% magnesia applied on the top. Most cheap and shoddy pipe coverings often used in iron and steel works and collieries, largely composed of clay and hemp fibre, rapidly drop to dust on prolonged contact with heated surfaces, quite apart from their poor insulation efficiency when first applied.

The high-grade pipe covering also contains no gritty material liable to fly about and get into bearings, is absolutely fireproof, and has no chemical action upon heated metal. In this connection 85% magnesia is unsurpassed, in addition to being of simple and known composition, containing the two products only.

Another important matter is the weight of the covering, especially when long steam-pipe ranges are concerned, and here again magnesia is excellent, since it is a light product. Finally it may be stated "Darlington" 85% coverings are supplied in all forms, including standard moulded slabs and sections, having an outer casing of canvas, asbestos, asbestos paper, asbestos cloth, or waterproof cloth secured with metal bands, forming a neat and efficient arrangement, while light sheet-metal detachable boxes for steam-pipe flanges are also available.

Canadian Base-Metal Production

In our last issue, a responsible authority discussed the Empire's growing independence in non-ferrous metal production. Since that was published the monthly letter of the Royal Bank of Canada for January further substantiates the information then given regarding Canadian production. With restriction of output of certain metals under discussion, the question is asked, why Canadian production has not been brought under regulation. The answer is given in this letter, which together with recent information published by the Dominion Bureau of Statistics at Ottawa, is given in this article.

PUBLIC interest in the spectacular rise in the price of gold and the rapid gain in the value of Canadian gold production has tended to obscure the noteworthy advances which have been achieved by the base-metal mines. Substantial gains have been made in the production of nickel, zinc, lead and copper, the greatest gain being of nickel, and the least that which took place in copper. A steadily increasing proportion of Canadian ores is smelted and refined within the country, with the result that both mining and allied industries have shown pronounced recovery through the expansion in world demand for these materials. Brief reference to these gains is given in the following reports :—

Nickel production.—Canada's nickel output, consisting of refined nickel, nickel in nickel oxides sold, and in matte exported, totalled last year 130,346,400 lb., valued at $30,674,000, as against 83,264,658 lb. ($20,130,480) in 1933. Last year's output was therefore higher than that of 1933 by 56%, and by 18%, as compared with the previous record year of 1929. During the year the number of converters at the International Nickel's Copper Cliff smelter has been increased from eight to twelve. This, with the additions which have been made to other smelter units, will enlarge the capacity of this company's plant considerably. Falconbridge Nickel Mines, Ltd., continued to ship copper-nickel matte to Norway for refining. During the summer, as a result of the magnetometric surveys, the existence of considerable bodies of ore was indicated at the British Columbia Nickel Mines, and these are now being tested by drilling and underground development.

Nickel exports by the International Nickel Company of Canada Ltd., were valued at $1,548,690 in November, as compared with $2,363,399 in November, 1933. The company's nickel exports during the first 11 months of 1934, however, were the highest on record, having been valued at $25,431,996, as against $19,616,609 in the same 1933 period, and with $5,810,708 in the first 11 months of 1932.

Lead and zinc production.—Lead production in Canada in 1934 is estimated at 342,811,000 lb., valued at $8,357,000, an increase of 29% over the 1933 total of 266,475,191 lb. ($6,372,998). The previous record year was in 1928, when 337,946,688 lb. were produced. Zinc production rose by 51% during the year from 199,131,894 lb. ($6,393,132) to 300,747,113 lb. ($9,169,000), being 12% greater than the total reported in 1930, the previous record year.

The principal source of Canada's lead and zinc production is the Sullivan mine in British Columbia, concentrates from which are treated at the smelter of the Consolidated Mining and Smelting Co., Ltd., at Trail, British Columbia. The Base Metals Mining Corporation, now developing the Monarch mine at Field, British Columbia, produces high-grade lead and zinc concentrates which are exported to Belgium, whilst refined zinc is produced by the Hudson Bay Mining and Smelting Co., Ltd., from ores mined at Flin Flon, Manitoba. Zinc is also recovered from the ores of the Britannia copper mine, on Howe Sound, British Columbia. Lead occurs with the gold-silver ores of the Premier mine, northern British Columbia, while some silver-lead concentrates were exported last year from the Mayo district, Yukon Territory.

Copper production.—Last year's copper output in Canada, amounting to 367,054,472 lb., was a record figure for the Dominion, exceeding the total for 1930—the previous highest year—by 21%, whilst the output of copper in 1933 reached only 299,982,448 lb., valued at $21,634,853, as compared with $26,881,000, representing the value of the 1934 production. The previous record production of 1930 was valued, however, at $37,948,359.

Of the total output of copper, 57% was produced from mines in Ontario, 20% from Quebec properties, 10% from Manitoba, and Saskatchewan, and 13% from British Columbia. Blister copper made at Anyox, British Columbia, is exported for refining, and concentrates made by the Britannia Mining and Smelting Company are shipped to Tacoma. In Eastern Canada the blister copper made at Flin Flon, Manitoba, and Noranda, Quebec, is refined by the Canadian Copper Refiners, Montreal East. Copper produced by the International Nickel Company, Ltd., is refined by the Ontario Refining Company, Ltd., at Copper Cliff, Ontario. Concentrates produced by the Consolidated Copper and Sulphur Co., Ltd., Quebec, are exported to the United States for smelting. On account of its excellent quality, Canadian refined copper is much in demand by foreign buyers, and is finding its way into ever-widening markets.

Regulation of World Production.

In view of the efforts which are being made to regulate the total world production of almost every individual metal except iron, it may be of some interest to know why Canadian production has not been brought under regulation by the cartels.

Almost every major ore body in Canada contains two or more minerals, so that base-metal mining operations have resulted in the production of more than one metal. From the standpoint of the individual mine, there is a possibility of better balanced activity as a result of these combinations. When the price of one metal falls to unprofitable levels, or that of another shows marked gains, mining operations can be correspondingly adjusted. Thus, one mine in British Columbia found copper prices too low to permit continuance of former operations, but was able to begin working on an ore body with a low copper content, and a relatively high zinc content combined with small percentages of gold. During the years of low copper prices, copper has been produced in Canada principally as a by-product in the recovery of other metals. The expansion of Canadian copper output has been the indirect consequence of increased production of nickel and gold. Thus the President of the International Nickel Company, in a recent statement to shareholders, said " In extracting nickel . . . approximately two pounds of copper are recovered for every pound of nickel. This means that copper is now being mined at the rate of more than 200,000,000 lb. per year, as the direct result of providing the nickel now required in diversified industrial markets throughout the world."

The Rouyn area of Quebec is another famous example. Developed and originally organised for the production of copper, low copper prices and the increasing values of gold caused the main emphasis to be placed on gold production, and copper was relegated to its present position as a by-product. Many of the Canadian mines produce small quantities of the precious metals—gold, silver, platinum and others of the platinum group—in their ordinary mining operations, and the sale of these precious metals has permitted the maintenance of base-metal operations during the depression.

The continued production of certain base metals, regardless of demand, has complicated the world market situation. The low production costs of such by-products has offered serious competition to the high-cost mines in other countries, and various measures have been taken to offset this competition. In 1932, the United States, formerly the dominating factor in the copper market, found it necessary to impose a duty of four cents per pound on all imports of copper, and other countries have taken similar action to protect domestic production or to aid mining in Colonial Possessions. In recent months, the rapid gain in output of low-cost copper in various parts of the world has forced producers to undertake negotiations for an international agreement for the curtailment of output.

The World Copper Situation.

It is the customary practice to divide world copper consumption under two headings, that consumed in the United States, amounting in normal years to approximately 50% of the total, and that consumed in other countries. It is a commentary both on the general trend toward world recovery and on the part that electric power is to play in the developments of the next few years that copper consumption in countries other than the United States during 1934 was at a rate in excess of the peak year 1928. Consumption in those countries in November amounted to 100,000 tons, the highest on record, compared with an average monthly consumption of 85,500 tons in 1928. As a further indication of the upward trend in the use of copper, the consumption of electrical energy in Canada is now 20% above the record of 1929. While part of the amount produced is consumed in electric boilers, even this use of electric power implies increased use of copper products.

In spite of the high rate of consumption, unofficial estimates of copper stocks in countries other than the United States have increased by 5,750 tons since January 1, 1934. There is some question, moreover, regarding the extent to which the high November record in foreign copper consumption was influenced by purchases in anticipation of the proposed copper cartel. Preliminary discussions of plans for international control of copper have been in progress over a period of months, and the final meeting will take place in New York in January.

There are four principal sources of copper—South Africa, Chile, Canada and the United States. The output in the first three countries has shown rapid expansion during the past year, and the percentage increases in African and Chilean production have been greater than in Canada. Part of the growth is attributed to the rapidity with which the famous Rhodesian mines have been placed on an operating basis. Costs of production in these countries are very low, and it is estimated that present world prices of approximately seven cents per pound provide an ample profit margin for many mines.

Since these South African and Chilean mines are primarily producers of copper, their output can be more or less readily adjusted to changes in world demand, and these countries, accordingly, will be forced to bear the brunt of any programme to balance world production and consumption. Canadian producers, while anxious to co-operate, point out that unless the world is prepared to do without its supplies of other necessary metals, their output of by-product copper cannot be reduced. This problem has been recognised by the other countries interested in the curtailment of output, and a proposal has been laid before the recent conference whereby American and other foreign producers of copper will endeavour to overcome this difficulty. Under this arrangement a joint pool will be formed to purchase Canadian by-product copper as it is offered, and to hold it off the market until conditions warrant its sale. Although such a plan appears to have the disadvantages inherent in the accumulation of stocks which may overhang and depress the market, it is considered the most practical method of removing one of the major obstacles to an international agreement.

Apart from this proposed pool to hold Canadian stocks, few details of the curtailment programme to be discussed at the New York meeting have been announced. It is understood, however, that the organisation may follow the system which has been successfully applied by the International Tin Committee, which controls world output of that metal. On this basis, production quotas for each signatory of the agreement would be fixed quarterly in relation to estimated world consumption. Reports vary as to the degree of restriction that will be imposed ; but it is generally believed that the original reduction in output will be 20%. As far as the United States is concerned, the plan will probably involve the restriction of exports and the regulation of output in order to prevent accumulation of stocks from current production.

Great Britain Imports of Canadian Base Metals.

Canada's principal outlet for metals is now in Great Britain, where, according to the Hon. W. A. Gordon, M.P., Minister of Mines of the Dominion of Canada, fully 56% of the Dominion's output of base metals is being absorbed. He states that nowhere has progress in metal exports been more pronounced than in the development of the United Kingdom market. The difficult problem Canadian producers of metal had to face when the United States built an almost unscalable wall around copper, zinc and lead has been largely solved through new preferences in Empire markets. This fact is indicated by export statistics. While between the years ending September 30, 1932 and 1934, Canada's aggregate annual exports of the above three metals and of nickel to the United States have fallen from some 210.7 million to only 106.4 million pounds, in the same two-year interval the annual exports to the United Kingdom of these products have climbed from 294.8 million to 541·4 million pounds. That the placing of more than half a billion pounds of these metals in a single market—the greatest importing market of the world—is an achievement of very great significance to the Dominion is perhaps more clearly indicated when it is pointed out that these metals realised for Canadian producers practically $31,000,000, compared with under $10,000,000 two years earlier.

Imports into the United Kingdom of Canadian base metals during the year 1934 included the following items, figures being given also for the years 1932 and 1933 :—

Metal.	1932.	1933.	1934.
Aluminium (crude, in ingots, blocks, etc.)	3,329 (Tons)	197,419 (Cwt.)	231,004 (Cwt.)
	£315,018	£877,201	£939,652
Copper, Electrolytic (unwrought, including rough copper of 94% copper content or over) .. .. .. (Tons)	30,238	36,754	56,731
	£1,097,676	£1,350,221	£1,892,042
Lead, Pig .. .. .. (Tons)	54,827	69,966	76,582
	£678,305	£841,085	£858,898
Nickel and Nickel Alloys (total imports from all countries ; value only)	£361,079	£463,652	£968,555
Zinc, Crude .. .. (Tons)	45,804	51,301	76,649
	£658,080	£868,884	£1,149,166

Corrosion tests were recently carried out in a large sewage disposal plant in America, with a view to discovering the most economical material to resist the attack of the sewage corrosive handled. The results obtained from specimens located in different parts of the plant show that cast iron and steel are attacked from four to twenty times faster than Ni-Resist and that copper is attacked from two to three times faster. The resistance to wear offered by Ni-Resist also adds to its value for components subjected to abrasion such as occurs in pump valves, screw conveyers and scrapers.

Recent Developments in Tools and Equipment

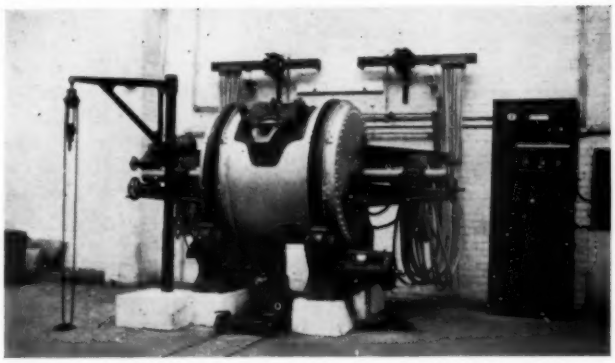


Fig. 1.—Detroit rocking arc furnace with a holding capacity of 1,000 lbs. recently built and installed in this country.

Birmingham Electric Furnaces Ltd. have recently acquired the sole manufacturing rights in Great Britain, the Dominions and several other countries, of the well-known Detroit rocking arc electric melting furnace. They are thus able to offer British-built equipment of this type, and are in the unique position of having at their disposal the 16 years' experience which the Detroit Electric Furnace Company have gained in the building and operation of this type of melting plant.

The Birlec-Detroit Rocking Arc Furnace.

THE Detroit rocking arc furnace is one of the most versatile electric melting appliances available to the metal producer. It has upwards of 600 users, who are melting regularly such diverse metals and alloys as brasses, bronzes, leaded bearing alloys, Monel metal, and other copper-nickel alloys, nickel-chromium-iron alloys for castings, cast and malleable iron, and stainless steel. Furthermore, in the same furnace it is possible to melt the majority of the above metals in consecutive charges if required. The furnace can be completely emptied after each heat, and thoroughly cleaned before a different alloy is melted. In this important respect it is more flexible than any other type of electric non-ferrous melting furnace.

The furnace is of a rugged design, and consists of a horizontal mild-steel cylinder lined with refractory and insulating materials. Fig. 1 shows a recently-built installation in this country, the holding capacity of this furnace being 1,000 lb. Two graphite electrodes enter on the axis of this cylinder forming an arc in the centre of the furnace. The arc is of the indirect type, and is independent of the charge being melted. The arc heats the underlying metal and the refractory walls mainly by radiation. The furnace is mounted on rollers, and is rocked about a horizontal axis. The rocking motion distributes the heat generated by the arc, always presenting new surfaces to radiation, and enabling the molten metal to wash practically the whole refractory lining, thus gaining the advantage of rapid heat transfer by conduction, and at the same time continuously cooling the refractory to improve its life.

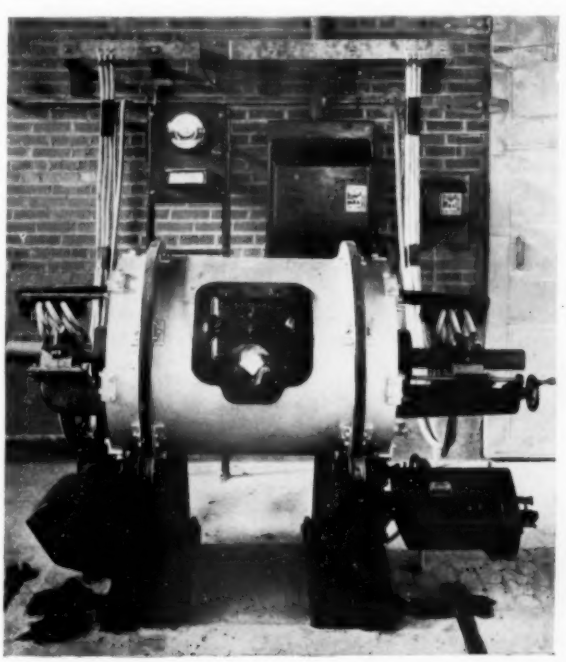
The rocking motion is automatic, and the angle of rocking adjustable. The furnace has only one opening which serves as a charging door and pouring spout. This feature considerably increases the thermal efficiency of the furnace, and enables the unit to be practically gas-tight. The power is controlled by varying the arc length, and this can be made automatic if desired. For the larger sizes of furnace automatic regulation is strongly recommended. The furnace is adaptable for direct pouring into ingot moulds or pouring into ladles or shanks for foundry work. It is made in a wide range of sizes to suit the requirements of practically all ferrous and non-ferrous users.

The types range from 25 to 50 lb. (25 k.w.) up to three tons in holding capacity. The smallest type is a most valuable unit for research laboratories and for works requiring small special melts and pilot heats. It should be remembered that the size of furnace is best measured in productive capacity, and since the Birlec-Detroit furnace melts more rapidly than any existing furnace, the size of plant required for a given output is only one-half to one-third that needed for other types.

Fig. 2 is an illustration of a 350 lb. holdiug capacity unit for ferrous or non-ferrous work. The continuous rocking motion of the furnace ensures that the molten metal is vigorously stirred, guaranteeing perfect uniformity of oemposition of the melt. Moreover, the degree of stirring can be controlled, which is impracticable in other types of melting furnace. Alloying elements are rapidly assimilated by virtue of the movement of metal, and when insoluble metals such as lead in copper alloys are to be incorporated, extreme uniformity in distribution is not only desirable, but essential. The following figures show the results obtainable on leaded bearing alloys :—

25·6% lead—first ingot from first ladle.
25·9% lead—last ingot from last ladle.

Fig. 2.—Detroit rocking arc furnace—350 lb. holding capacity.



It will also be appreciated that the rocking motion considerably increases the rate of heat transfer by presenting new surfaces to radiation, whilst it protects the metal against local over-heating. For this reason the Birlec-Detroit rocking arc furnace is claimed to be the most rapid melting appliance in non-ferrous and ferrous foundry practice. Copper alloys can be melted in 25 to 30 min., whilst melting time for ferrous alloys, including cast iron, is approximately 50 to 60 min. depending upon the rating and size of furnace.

The furnace operates with a perfectly reducing or neutral atmosphere, and gas analyses do not reveal more than a trace of free oxygen during the melting period. Consequently, the furnace is capable of melting light scrap, such as swarf, turnings, borings, sheet clippings, etc., with practically no loss of metal by oxidation. When alloys containing such readily oxidisable metals as chromium, zinc, aluminium, vanadium, etc. form part of a charge, very substantial savings result from the use of the rocking arc furnace. These additions can be charged at the beginning of the heat with the certainty that they will be present in the alloy in the same proportions as charged. Some typical average metal losses are given in the following table :—

Cast-iron borings	2 to 3% loss
Cast-iron solid scrap	1% loss.
Bronzes and Red Brass	·3 to ·6% loss.
Brass (60/40)	·6 to 1·0% loss.

In view of the highly reducing atmosphere in the furnace, it should be noted that there is no necessity for providing a protective slag or flux as is required in other melting furnaces.

Advantages.

The many advantages of this type of furnace have relative values varying according to the work on which the furnace is engaged. Generally, in melting non-ferrous alloys, it is often useful to be able to change the composition of the alloy in successive melts, and yet secure an accurate analysis in each charge. In alloys containing lead, zinc, etc., the almost complete absence of loss by evaporation or oxidation is of great value, and alloys containing up to 50% lead may, for instance, be melted in this type of equipment with success.

In melting ferrous metals the absence of a slag coating on the bath is useful, while the thorough mixing of the metal is of particular importance, since it results in the thorough solution of carbon and the uniform dissemination of other constituents throughout the charge. When dealing with iron in particular, this rocking furnace has been found particularly useful since the agitation of the metal has a rapid degasifying action, and also decreases the sulphur content of the iron. In making high-test grey iron, the accurate reproduction of any desired analysis is valuable, and, further, the rocking action has been found in actual practice to effect considerable increase in the strength of the metal. The economic value of being able to use light scrap of various kinds is also of considerable importance.

Maintenance.

The refractory life is long, as the lining is prevented from overheating by the rocking motion of the furnace allowing the metal to wash the refractory. Much, however, depends, as in every other melting furnace, on the conditions obtaining in each installation, and the method of working. The following figures for refractory life are quoted as being representative of best average practice :—

Brasses and Bronzes :	Small furnace 200 to 400 lb. = up to 6,000 heats—average 3,000. Larger furnaces, 1,000 to 1,200 heats, occasionally—2,000 heats.
Copper-nickel Alloys :	600 to 1,500 heats, depending upon the size of furnace, etc.
Cast Iron and Steel :	Depends upon operating conditions—pouring temperature, composition of metal, and patching practice.

The most important factor is the over-all refractory cost per ton, and for non-ferrous metals this ranges from 1s. 3d. to 3s., while, for ferrous material, it is of the order of 4s. to 5s. per ton of metal melted.

The electrode consumption for non-ferrous metals ranges from 2½ lb. to 5 lb. of graphite per ton, and for ferrous alloys 7 lb. to 8 lb. per ton.

Due to the rapid melting characteristics and its high thermal efficiency, the consumption of energy is extremely low, and the following figures are quoted as being typical of average practice :—

	Continuous Working. Kw. hrs. per ton (2,240 lb.).	Day Working. Kw. hrs. per ton (2,240 lb.).
Yellow brass (60/40) ..	230	275
Red brass (70/30) ..	280	315
Bronze	290	320
Cast iron	570	630

The fact that probably over 80% of electrically melted non-ferrous metals in the foundry, and a large proportion of electrically melted cast iron are produced in Detroit rocking arc furnaces is testimony to their reliability and economy, and is worth investigation by every producer of ferrous and non-ferrous alloys—no matter how small or large his output, or how varied are his mixes.

U.S. Mine Production of Gold and Silver.

AN advance summary of the United States reports shows that the higher prices paid for domestic mine silver under the regulations and orders promulgated in December, 1933, had no effect on the production of silver before the end of the year, as only about 1,100 oz. of domestic silver received the benefit of the increased price. Also, while higher prices paid for gold from August to December stimulated development and added materially to profits of mine operators, they did not greatly increase the quantity of gold produced in 1933. There was actually a decrease in the quantity of domestic mine gold recovered in continental United States, but mines in the Philippine Islands had an increased yield of 80,742 oz. in 1933, and the output was four times as much as it was in 1924.

About 7,000 mines contributed to the output of gold and silver in 1933 ; many were very small operations, as 70% of the entire yield of gold (Philippine Islands and Puerto Rico excluded) represented the output of 25 companies. The mine output of silver from the 25 leading producers was about 86% of the total silver, and eight of the 25 had an output of more than 1,000,000 oz. each. Also, about 25% of the domestic gold was derived from placers, and of this nearly 70% was recovered by 64 gold dredges ; thus, nearly 3,700 other placer operations each yielded only an average of about 40 oz. of gold.

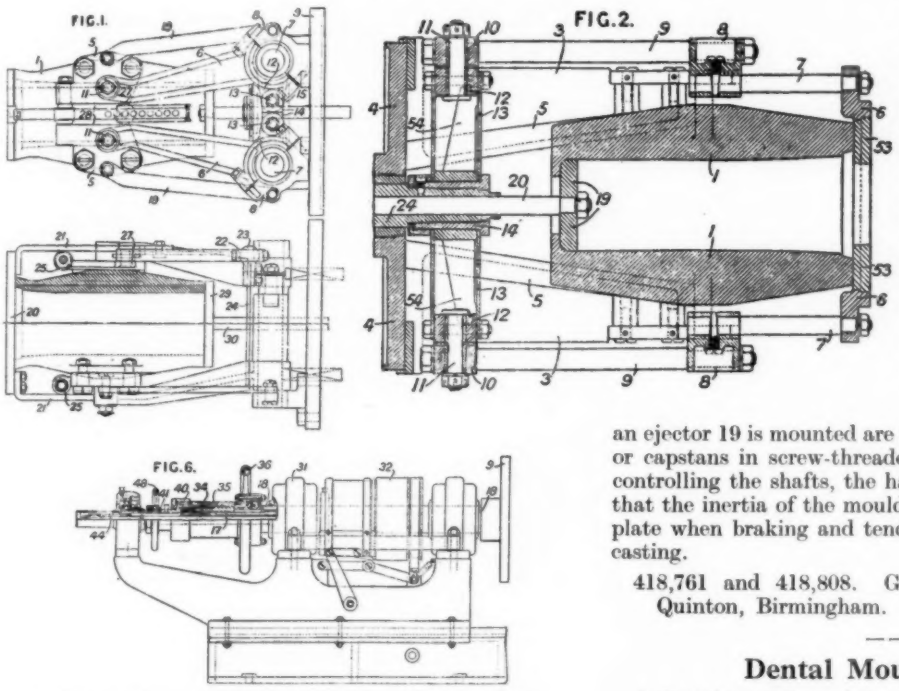
For the first time in many years the quantity of copper ore (containing gold or silver) treated in 1933 was less than the quantity of dry and siliceous ore treated. The copper ore treated in 1929 was 62,140,800 tons, as compared with only 8,363,600 tons in 1933, whereas the quantity of dry and siliceous ore treated increased more than 1,350,000 tons during the same period. One of the reasons why the gold production of the United States has not greatly increased is that the gold derived from copper ore has decreased more than 352,000 oz. since 1929. The great decrease in the quantity of base ores containing gold and silver treated in the United States is shown by the fact that in 1929 about 67,989,000 tons of base ores yielded 334,106 oz. of gold and 49,707,013 oz. of silver, while in 1933, 10,512,347 tons of base ores yielded 162,544 oz. of gold and 19,452,660 oz. of silver. The dry and siliceous ores yielded an average of 0·18 oz. of gold and 0·42 oz. of silver a ton in 1933, and 10,512,347 tons of base ores (containing gold and silver) yielded 0·015 oz. of gold and 1·85 oz. of silver. It is evident that with the mining of base ores at low ebb any large increase in the domestic mine output of gold must come from placers and from dry and siliceous ores. Furthermore, as there are only a few mines now operating at which silver is the important metal recovered, increased silver output must await an expansion in the quantity of base ores treated.

Some Recent Inventions

The date given at the end of an abridgement is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.

Centrifugal Casting Machines.

MUCH progress has been achieved during recent years in the development of centrifugal casting machines. In a recent development of this character, in which a divided mould is employed, the parts are held together or separated by levers or bell-cranks pivotally mounted on a rotatable face plate and positively operated by axial movement of a member in alignment with the axis of the mould. The parts of the mould 1 preferably have stepped engaging surfaces, and have webs, shaped to assist cooling, to which are bolted plates 5. Levers integral with spindles in bearings on a rotatable face plate are pivoted to plates 5, inwardly extending portions of the levers carrying pivot pins extend through brass blocks 14 radially slidable in a block 15. Links ensure vertical movement of the mould parts. The block 15 is slidable on a bush secured on the end of a hollow shaft 17, Fig. 6, extending through the shaft 18 of the face-plate 9, axial movement of the block opening or closing the mould, and springs urging the parts to the closed position. The pins 13 may be partly eccentric for relative adjustment of the levers 6 and the mould parts. A ring 20 for closing the end of the mould during casting is carried on straps 21 secured by ball and socket joints 22, 23 to a transverse spring plate 24 on the shaft 17, axial movement of which moves the plate to the mould, or away therefrom to allow it to swing about its pivots 23. The ring is located laterally by cams 25 engaging the straps 21, and vertically by rollers 27 on the straps engaging between faces 28 on the plates 5. The straps are preferably adjustable in length. A plate 29 closing the opposite end of the mould is controlled by an axially movable rod 30 within the shaft 17. The shaft 18, Fig. 6, is carried in bearing blocks 31 and is rotated by a belt pulley 32. The shaft 17 carries a member 34 in screw-threaded engagement with a sleeve 35 rotatable by a hand-wheel 36 to produce axial movement of the shaft, with the bush supporting the block 15 and plate 24. The rod 30 controlling the plate 29 carries a screw-threaded member 44 engaging a sleeve 41 secured to the sleeve 35 by a clamping ring 40, the engagement being adjustable by a hand-wheel 48 on releasing the member 40. The hand of the screw-threads is such that the inertia of the mould assists the required movements on starting or stopping. Positive means for ensuring that the mould is closed before replacing the end ring, and for locking the mould parts, may be provided. One part only of the mould may be movable. A sheet metal guard of horseshoe outline and channel section may be mounted on longitudinal bars movable on rollers to or from the mould.



Various views of a recently developed casting machine.

Special attention is directed to the ring which is axially movable relative to the mould and which may be swung out of alignment with the end of the mould. The end of the mould is partly closed during casting by a ring 53 Fig. 2 in a housing 6 which is secured to rods 7 connected through brackets 8 and rods 9 to members 10 mounted on pivots 11. Bosses 12 carrying the pins 11 are supported through leaf springs 13, a yoke 54 preventing the springs from operating when the ring is being moved away from the end of the mould. The plate 53 is moved axially towards or from the mould by movement of a shaft 24 and swings downwardly about the pivots 11 when away from the mould. Lever mechanism controlled by a pedal may raise the ring into alignment with the mould before it is moved thereagainst, and guides are provided to secure registration. The shaft 24 and a central shaft 20 on which an ejector 19 is mounted are moved axially by hand-wheels or capstans in screw-threaded engagement with members controlling the shafts, the hand of the threads being such that the inertia of the mould assists the release of the end plate when braking and tends to tighten the plate during casting.

418,761 and 418,808. G. WILLIAMS, Russell House, Quinton, Birmingham.

Dental Mould Material.

A dental mould consists of a highly refractory material such as silica, alumina etc., and a binder of silica gel. In making the mould the silica gel is preferably generated *in situ* by admixing hydrolysable organic silicates with the refractory material and initiating aggregation of colloidal silica particles as by admixing with the ester a small amount of acid. The initial setting may be accelerated by heating *e.g.*, to 110 to 115° C., or by adding a small amount of an accelerator, *e.g.*, an alkaline material, preferably magnesium oxide. In an example, 8 vols. of tetra-ethyl silicate are mixed with 1 vol. of water, and a few drops of hydrochloric or sulphuric acid, the mixing being aided by the addition of 1—2 vols. of ethyl alcohol or acetone. The mixture is then stirred on a water bath for about 1—2 hours ; 1 part of the binder being then mixed with 2 parts of silica (ground quartz). To accelerate setting magnesium oxide may be mixed with the silica in the proportion of 1 : 1,000 or ammonium hydroxide with the binder in the same proportions. The highly refractory nature of the composition allows its use in soldering or welding processes or for the casting of high fusing materials. The surface of a completed mould may be hardened by painting it with or immersing in the liquid binder.

418,160. AUSTENAL LABORATORIES, Inc., 34, West 33rd Street, New York, U.S.A.

METALS IN THE FOOD INDUSTRY.

THE food chemist is as jealous of the purity of his product as the chemical manufacturer is of the purity of his fine chemicals, and one of his primary considerations must be the suitability or otherwise of the metals at his disposal, said Mr. N. D. Sylvester at a recent meeting of the Birmingham and Midland Section of the Society of Chemical Industry. In considering the suitability of a metal for a food process, he stated, three things must be considered. The first is the effect of the metal on the food and the amount of metallic contamination, the second is the effect of the food on the metal, and the third is the effect of washing and cleansing solutions on the metal.

The action of washing and cleansing substances on the plant is of great importance and is often more serious than the action of the food. The metallic contamination of the food is of course a matter of primary importance, and so far as possible it should be reduced to a minimum. The question of toxicity of the metal must be considered, as the presence of the slightest traces of a metal such as lead cannot be allowed, and no metal or enamel containing arsenic or antimony can be used in the food industry. The recent development of cadmium platings has made a further addition to the list of prohibited metals. Quoting a number of examples of foods affected by different metals, Mr. Sylvester said it was interesting to note that the presence of one part of copper in 40 million parts of butter had recently been shown to have a marked effect on the keeping properties of the butter. The presence of copper in milk was one of the causes of the development of tallowy flavours, and iron showed a similar but less marked influence.

Among the more important factors influencing the extent of the corrosion of metals by foods were :—temperature, time of contact, presence or absence of air, formation of protective films derived either from the food or from the metal—which might protect the food from contamination or the metal from further corrosion—and lastly the cleanliness of the plant. On this question it should be remembered that operatives take a pride in keeping plant spotlessly clean when the results of their labours are readily apparent, therefore it is a definite advantage to use a constructional metal which looks clean when it is clean. The modern stainless alloys are admirable in this respect.

Iron and mild steel are the widest used metals in the food industry as in most other industries, especially for machinery parts with which food does not actually come into contact. The modern tendency, which gives improved performance, is to modify the iron and steel by the addition of other elements. Certain of these products stand out in a class by themselves, and their corrosion resisting properties render them especially suitable for use in a very large section of the food industry, covering vinegar, sauces, salt and salt water, acid fruits and juices, fresh and sour milks, fish pastes, onions, coffee, etc. Further they are resistant to alkaline washing compositions.

The idea of lining a base metal with a resistant material has found further expression in the more recent production of ply-metals where a backing of, say, mild steel is faced with stainless steel or with nickel. Such products are not so expensive as the pure resistant metal and should find extensive use. An enormous amount of research has been carried out to elucidate the corrosion which occurs inside a tin can, and the result is that to-day an increasing range of foodstuffs can be preserved by canning.

Copper is not, judged by modern standards, a suitable metal for use in the food industry, but in the milk industry and the food industry as a whole, tinned copper has found fairly extensive application. Chromium plating has not found an appreciable use in the food industry, but if the quality could be improved to the present reliability of, for example, nickel plating, it should have many applications. The use of silver, in view of the fall in price, has increased and plant lined with silver sheet is particularly resistant to acetic acid vapours.

Mr. Sylvester dealt at some length with nickel and its alloys, mentioning especially Inco chrome nickel, or Inconel. Such metal, he said, appeared to be ideal for food processing in general, and where cleanliness and freedom from metallic contamination were matters of greatest importance, as in mayonnaise manufacture, and in the preparation of fruit essences.

Aluminium was suitable for use with acid foodstuffs, such as fruit, but it was necessary to observe the greatest care as regards cleanliness. The numerous aluminium alloys were mostly constructional materials and found no appreciable use in the food industry, though, Birmabright, a corrosion-resisting alloy containing magnesium, was suitable for use in all cases where aluminium was suitable and its performance was generally superior. It should be suitable for almost any conditions ordinarily met with in the food industries.

Reference was made to the production of oxide films on aluminium and its alloys which could be coloured with suitable dyes to manufacture very attractive products. He was not aware that oxidised aluminium had as yet found application in food plant, and its lack of resistance to abrasion must necessarily restrict its use in that direction. It should be remembered however, that the corrosion resistance of metals in practice is not always that which would be expected, and it sometimes happens that a metal is satisfactory in one case, but not in a second when conditions are thought to be identical.

Tapered Roller Bearings in Rolling Mills.

THE interesting prediction that the pressure of competition will, in a few years, necessitate the general adoption of roller bearings throughout the metal-rolling industry, was made by Mr. E. H. Doughty in a paper recently read on the above subject before the Scottish branch of the Institution of Mechanical Engineers. He described various types of one-, two-, and four-row tapered roller bearings used in rolling mill equipment, including the largest sizes for roll-neck mountings, which are capable of carrying loads of from 6,000,000 lb. to 7,000,00 lb.

Discussing the economies which result from the use of tapered roller bearings in place of plain journals, the chief of these, he said, are a 25% to 50% saving in power, which means a corresponding saving in first cost of motors and driving gears, a greater output, thanks to higher rolling speed, a greater accuracy of product, thanks to the elimination of bearing wear, a long-service life for the bearings, an improved service from pinion stands and gears because of the absence of bearing wear and maintenance of shaft centres, and savings in lubrication and maintenance costs. The extent of these economies was illustrated with detailed figures derived from current practice.

Mr. Doughty also explained mountings for vertical rolls for universal mills, roll neck and thrust blocks for tube-piercing mills and for pinion stands ; reduction gears, hot saws, live rollers, coiler shafts, and general transmission gears.

Aluminium Coins.

AN interesting new application of the use of aluminium has recently occurred. A large quantity of 3 SH commercial finish sheet has just been sold to the Paraguayan Government for coinage. In view of the fact that the price of silver has risen and with most countries off the gold basis there are possibilities of its extensive use.

The intrinsic value of the metal in such coinage has little or no relation to the value of the coin itself these days, and since an aluminium coin made out of a cheap alloy such as 3 S, can be very easily manufactured, is cheap, attractive, durable and non-corrosive, there is reason to believe that other countries will find it useful for this purpose, and that it will appeal to the public.

Business Notes and News

Merger to Manufacture Carbon and Graphite Electrodes.

The electro-metallurgical, electro-chemical and other industries of Great Britain, which have for years been largely dependent on supplies of graphite and graphite electrodes from outside the country, will be interested to learn that these products will shortly be manufactured in England. A merger has taken place between The Electrode Company of Sheffield, Ltd., well-known producers of amorphous carbon electrodes, and the Acheson Graphite Corporation, for years the leading suppliers of graphite electrodes, resulting in the formation of British Acheson Electrodes, Ltd., which company will manufacture and sell both carbon and graphite electrodes as well as graphite powders.

The company is capitalised at £150,000, all of which has been paid up. The Chairman is Mr. C. W. Kayser, Chairman of Kayser, Ellison and Co., Ltd., and previously Chairman of The Electrode Company of Sheffield, Ltd. The Managing Director is Mr. Arthur M. Williamson, who has been associated with Acheson interest for many years in America and Europe. Acheson engineers and manufacturing experts are already in Sheffield and construction and equipment purchases will be commenced at an early date, with the expectation that by the end of the year definite production of graphite will be realised. The amorphous carbon business will also be continued and alterations are being made in the equipment in line with the latest technique. Mr. P. M. Chetwynd Stapylton, formerly Manager of The Electrode Company of Sheffield, Ltd., will be in charge of the enlarged facilities at the Wincobank Works, Sheffield, and all of the former staff will be associated with the new enterprise, in collaboration with American experts in the supervision of the process.

The British Acheson Electrodes, Ltd., have opened administrative and sales offices at Town Hall Chambers, 87, Fargate, Sheffield, 1.

Soviet Orders Placed in Britain.

Arcos, Ltd., announce that they have completed negotiations for the placing of large orders in this country for various machinery and equipment involving a sum of more than £1,000,000 on a cash basis for shipment to the Soviet Union. The orders are to be executed in a period from three to twelve months, and are distributed over Manchester, Birmingham, Sheffield and Scotland. Several groups of factories are involved beginning with the production of the raw materials to the finished product.

One of these orders, which involves about £500,000, is for sets of railway wheels, axles and tyres complete, to be delivered in about six months. The fulfilment of this order will require about 30,000 tons of steel. Another order of interest to the engineering industry is one for machinery and equipment for Soviet paper factories. This is the first time that such equipment has been ordered here. Some 25,000 tons of various steels are also included in the requirements.

The Coppee Company (Great Britain) Limited, of 44, Grosvenor Place, London, S.W. 1, have received the order for an Ore Sintering Plant from the Millom and Askam Hematite Iron Company Ltd., to be erected at their works at Millom, Cumberland, on the Coppee Company's well-known A.I.B. system. The capacity of the plant to commence with will be 500 tons of screened sinter per 24 hours, but the buildings are being installed of sufficient size for the necessary additional apparatus, so as to be able to increase the throughput of screened sinter to 700 tons per 24 hours, if desired at a later date. This installation will be on the principle of that installed some years ago at the Cardiff works of Guest, Keen and Nettlefolds Ltd., but on improved lines, and will embody a system for the elimination and collection of dust.

An order for an installation of electrically-driven, mechanical grease-pumps to be used for lubricating the giant dock pumps that will operate at the new King George V. Dock at Southampton, has been secured by Tecalmit Ltd. The new dock, which is the largest in this country, will be the first British dock to use pumps lubricated by this mechanical system.

Ship Repairs.

A valuable ship-repairing contract has been obtained by Wallsend Slipway and Engineering Co., Ltd. The firm are to carry out repairs and build new engines for the Sacramento Valley, which was seriously damaged when she was recently stranded in the River Severn. It is an extensive contract and involves the building of new triple-expansion engines and considerable repairs to the bottom of the vessel. The Sacramento Valley is owned by Sir William Reardon Smith and Co., of Cardiff.

Shipbuilding Revival.

Satisfactory evidence of the renewed activity in shipbuilding is given in the annual summary of Lloyds Register for last year, and what is of special importance to us is that this country holds a commanding lead. Of the 536 vessels of 967,419 gross tons put into the water in 1934, a little over 47% was built in Great Britain and Northern Ireland. And, there were under construction in British yards at the beginning of 1935, nearly 37,000 tons more than the total construction of the previous year amounted to. This is a good augury. The general improvement is being felt in all British yards, particularly on the Tyne, which has suffered very heavily from the depression. Recent orders in fact have made the Wallsend firm of Messrs. Swan Hunter and Wigham Richardson one of the busiest of yards. Since the beginning of the year four orders have been obtained, including two for 9,250 ton tankers, and there are now about a dozen vessels on hand. These tanker orders are a few of other contracts to be placed, and the outlook is certainly brighter than for some years past.

Powerful Turbine for Power Station near Leningrad.

A 100,000-k.w. steam turbine is at present being designed at the Turbine Bureau of the Stalin Plant in Leningrad. It is said that when completed this turbine will be the most powerful of its kind in the world. The most powerful turbine so far produced by this plant has a capacity of 50,000 k.w. only, but, in spite of its great increase in capacity, the size and weight of this new turbine will not exceed that of the former. This will be made possible by doubling the number of revolutions per minute at which the turbine operates from 1,500 to 3,000.

Investigations carried out in the plant laboratory are claimed to have proved that Soviet steel is of such quality that no damage can result from the increase in the number of revolutions. The actual increase in capacity will be largely due to the introduction of a new and extremely efficient type of blade designed by the engineers of the bureau under the direction of M.I. Grinberg. The use of this blade and other innovations it is stated, will make it possible to pass proportionately greater quantities of steam through the turbine than has yet been possible. When completed, the turbine will be installed at the Dubrovski Steam Power Station near Leningrad.

Royal Aeronautical Society.

The recent Air Race from Mildenhall to Melbourne has done more to rouse an interest in aviation than any similar event of recent years. It has, indeed, shown what are the amazing possibilities for the future of air transport and has drawn attention to the vital importance of the great Imperial Air Routes.

The race drew the attention of everyone to two very remarkable aeroplanes, the De Havilland Comet which flew from Mildenhall to Melbourne in less than three days and the Douglas Air Liner which, by the way it kept to the regular time table, became known as the Flying Train.

The Council of the Royal Aeronautical Society have great pleasure in announcing that Captain G. de Havilland, who was responsible for the design of the Comet and who, last May, was awarded the British Gold Medal for Aeronautics by the Society for his work on aircraft, will lecture before the Society on "Commercial Aeroplanes" on April 12, 1935.

As the name of Captain G. de Havilland is one of the best known names in Civil Aviation in this country, so is that of Mr. W. D. Douglas, the designer of the Douglas Air Liner, in America. It is with very great pleasure that the Council are able to announce that Mr. Douglas has accepted the Council's invitation to visit this country next May and deliver the Wilbur Wright Memorial Lecture on his work.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£78	0	0
Chinese	69	10	0
Crude		—	

BRASS.

Solid Drawn Tubes	lb.	8¾d.
Brazed Tubes	„	10¾d.
Rods Drawn	„	8d.
Wire	„	7d.
*Extruded Brass Bars	„	3¾d.

COPPER.

Standard Cash	£57	5	0
Electrolytic	30	10	0
Best Selected	29	5	0
Tough	28	15	0
Sheets	58	0	0
Wire Bars	30	10	0
Ingot Bars	30	10	0
Solid Drawn Tubes	lb.	9½d.	
Brazed Tubes	„	9½d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	3
‡Ferro Tungsten	„	0	3	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL 2–4% Carbon, scale 11/- per unit	ton	29	15	0
NOMINAL 4–6% Carbon, scale 7/- per unit	„	23	0	0
NOMINAL 6–8% Carbon, scale 7/- per unit	„	21	12	0
NOMINAL 8–10% Carbon, scale 7/- per unit	„	21	12	6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	33	17	6
Guar. max. 1% Carbon, scale 12/6 per unit	„	37	12	6
§Guar. max. 0·7% Carbon, scale 15/- per unit	„	42	0	0
‡Manganese Metal 97–98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	5
§ Ferro-Vanadium 25–50%	„	0	12	8
§ Spiegel, 18–20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	17	6
45/50% basis 45%, scale 5/- per unit	„	13	17	6
70/80% basis 75%, scale 7/- per unit	„	18	5	0
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	14	0	0
§ Ferro - Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	14	16	0
§ Ferro-Molybdenum, Molyte	lb.	0	4	6
§ Calcium Molybdate	„	0	4	2

FUELS.

Foundry Coke—				
S. Wales	—	1	5	0
Scotland	—	1	8	0
Durham	1 0 0 to	1	5	0
Furnace Coke—				
Scotland	—	1	5	0
S. Wales	—	1	0	0
Durham	—	0	17	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£53	0	0
*Commercial Ingots	39	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 9
*Cored Bars	„	0	0 11

LEAD.

Soft Foreign	£10	5	0
English	12	10	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	10	10	0
Best Bars	10	2	6
Common Bars	9	5	0
Lancashire—			
Crown Bars	9	12	6
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £7 10 0 to	8	0	0
Gas Strip	10	12	6
S. Yorks—			
Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	10½d.
†Sheet to 10 W.G.	„	10½d.
†Wire	„	11½d.
†Rods	„	10½d.
†Tubes	„	1/1
†Castings	„	10⅝d.

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
N.E. Coast—			
Hematite No. 1	3	8	0
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	10	0
Forge	3	6	6
Midlands—			
N. Staffs Forge No. 4	3	7	0
„ Foundry No. 3	3	11	0
Northants—			
Foundry No. 1	3	10	6
Forge No. 4	3	2	6
Foundry No. 3	3	7	6
Derbyshire Forge	3	6	0
„ Foundry No. 1	3	14	0
„ Foundry No. 3	3	11	0
West Coast Hematite	3	7	0
East „ „	3	8	0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 19·40 to £1 approximately.

Pig Iron Kr. 103
Billets Kr. 240-290 £13 10 0–£16 0 0
Wire Rods Kr. 280-320 £15 15 0–£17 12 6
Rolled Bars (dead soft) Kr. 200-220 £10 12 6–£11 11 0
Rolled Charcoal Iron Bars Kr. 290 16 0 0
All per English ton. f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£25	0	0
„ Braziery	20	0	0
„ Wire		—	
Brass	16	10	0
Gun Metal	23	0	0
Zinc	8	10	0
Aluminium Cuttings	66	0	0
Lead	9	10	0
Heavy Steel—			
S. Wales	2	15	6
Scotland	2	10	0
Cleveland	2	12	0
Cast Iron—			
Midlands	2	7	6
S. Wales	2	11	0
Cleveland	2	12	0
Steel Turnings—			
Cleveland	1	15	0
Midlands	1	14	0
Cast Iron Borings—			
Cleveland	1	5	0
Scotland	1	17	6

SPELTER.

G.O.B. Official		—	
Hard	£10	10	0
English	13	2	0
India	12	5	0
Re-melted	13	0	0

STEEL.

Ship, Bridge, and Tank Plates			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	8	10	0
„ „ (Marine) „		—	
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ⅛ in. to ¼ in.	„	3d.
Under ¼ in. to 5/16 in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£227	15	0
English	227	10	0
Australian		—	
Eastern	227	0	0

Tin Plates I.C. 20 × 14 box 18/2

ZINC.

English Sheets	£23	0	0
Rods	26	10	0
Battery Plates		—	
Boiler Plates		—	

* McKechnie Brothers, Ltd. Feb. 12. † C. Clifford & Son, Ltd., Feb. 12. ‡ Murex Limited, Feb. 12.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, Feb. 12.